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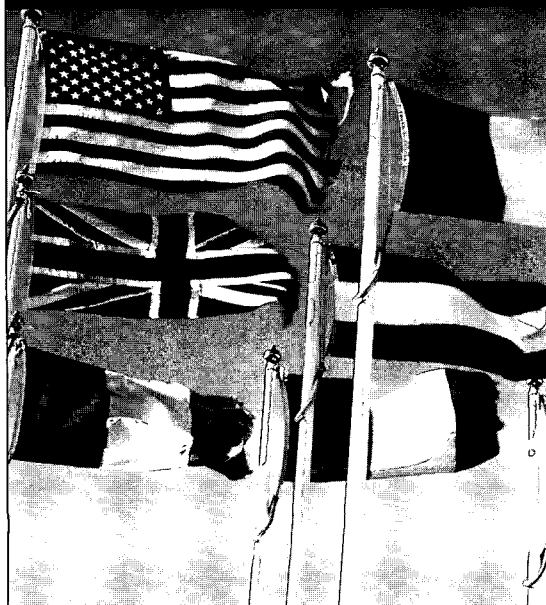
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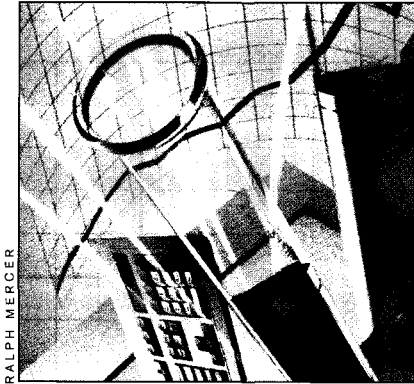
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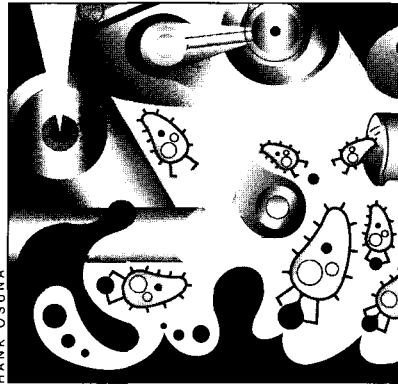
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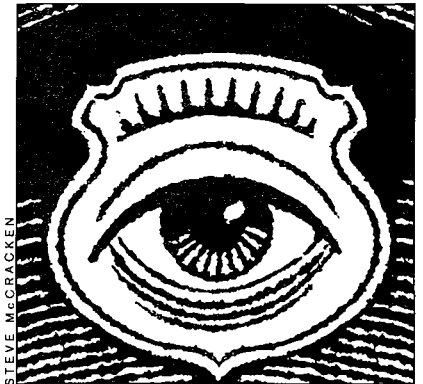
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COVER ILLUSTRATION
BY RALPH MERCER

A CONSIDERED OPINION

BY THOMAS E. MANN

Why a Presidential Dead Heat in 2000?

As riveting and historic as the weeks-long post-election struggle to determine the winner of the 2000 presidential contest has been, a prior question begs to be answered. Why didn't Vice President Al Gore win in a walk? The nation enjoys unprecedented peace and prosperity. President Bill Clinton's job approval ratings are consistently among the highest of any modern president. The Democratic party is near the center of the ideological spectrum and champions policies at the top of the public's agenda. How did we get to the point where a few hundred votes in Florida would determine who would be the next president of the United States?

To be sure, many Republican activists, lulled by George W. Bush's double-digit lead in trial-heat polls early in the election season, assumed that the Democratic hold on the White House would almost certainly end. Near the end of the campaign, Bush opera-

tives were confidently predicting a comfortable victory—as large as 6–8 percentage points in the popular vote and 320 or more electoral votes.

But the weight of scholarly opinion throughout the year suggested a Democratic victory. Election forecasting models developed and tested



DAY WALTERS/PHOTOGRAPHIC ILLUSTRATION

by political scientists over the past decade and a half underscored the advantage enjoyed by the incumbent party when economic times are good and the public approves the president's performance in office. While the models vary in their measures of the economy and public opinion, all embrace a conception of presidential elections as referendums on the performance of the incumbent administration.

While the models were unanimous in forecasting a Gore victory in the popular vote (correctly, it now appears)—with

forecasts ranging from 52.8 to 60.3 percent of the two-party vote for Gore—the basis for confident forecasts is shakier than it seems. Many of the models had been reformulated after serious errors in forecasting the 1988 and 1992 elections. All are based on short time series. All are highly sensitive to particular assumptions and measurement decisions. All have wide confidence intervals around their point predictions.

Nonetheless, the forecasting models usefully identify the broad context of presidential elections and set a more reasonable baseline for viewing the campaigns than the breathless, ever-changing commentary from pollsters and pundits. And in 2000 that baseline expectation was that the election was Al Gore's to lose. Why instead did we have a virtual dead heat? Any one of the following might have been decisive.

First, the economy might not have had the potency suggested by the forecasters. Some argue that its performance (as measured, for example, by real disposable income per capita) has been middling, not great. Others contend it has been too good too long to have any political bite and that the credit for good economic times is widely dispersed, not centered on the incumbent administration. The exit polls lend little support to either argument. Voters reported a buoyant national economy and markedly improved personal financial conditions. Those indicating that the economy mattered most in their vote choice gave Gore a 22 percentage point advantage over Bush. And yet this group was less than a fifth of the electorate, suggesting that the election was framed less as a referendum on good economic times than might have been possible.

Second, Clinton's high job approval rating may not have captured the public's more nuanced assessment of his presidency. After all, he (along with his pursuers) subjected the country to a long, painful scandal and impeachment in 1998 and early 1999. Most Americans were appalled by his behavior; he never regained the personal standing he enjoyed before the scandal. Gore won 85 percent of the vote of those who gave Clinton high marks both on the job and personally; but among the fifth of the electorate who approved Clinton's job performance but viewed him unfavorably as a person, Gore won only 63 percent of the vote. That difference alone could account for Gore's subpar showing on election day.

Potentially even more consequential were the scandal's indirect effects. Gore never felt comfortable running on the Clinton-Gore record. His obsession with separating himself from Clinton and running on the future, not the past, kept him from sharply framing the election as a referendum on good times.

Thomas E. Mann, the W. Averell Harriman Senior Fellow in the Brookings Governmental Studies program, is co-editor, with Norman Ornstein, of The Permanent Campaign and Its Future.

And Clinton himself, one of the most effective politicians in U.S. history, was perforce relegated to fundraising and selective forays into Democratic strongholds. The evidence was overwhelming that he would have done more harm than good with swing voters in battleground states. Imagine how different the Democratic campaign would have been had the words "Monica Lewinsky" never entered the political lexicon.

Another fallout from the Clinton scandal was the mobilization of social conservatives and the accentuation of the cultural divide in American politics. The evidence is to be found in Gore's poor showing in states like West Virginia, Tennessee, and Arkansas, as well as in the striking differences in candidate support between urban dwellers and those who live in small towns and rural areas. Peace and prosperity and the Democratic agenda on debt repayment, Social Security, and health care might well have trumped traditional values had the Clinton-Lewinsky affair not offended those who were torn between economic and cultural considerations. Progress made by the Democrats earlier in winning back social traditionalists was aborted.

This leads directly to a third possible explanation for Gore's failure to win comfortably. Some argue that in his populist rhetoric, aggressive efforts to mobilize the party base of minorities and union households, and vigorous opposition to the partial privatization of Social Security he lost crucial support among moderates and new economy workers. But the evidence is decidedly mixed. Gore ran on a platform fully compatible with the Clinton agenda. Gore's populist attacks were limited in scope, focusing on particular problems of great public concern—the high cost of prescription drugs, the arbitrary denial of treatment by health maintenance organizations. And he leavened these attacks with vigorous advocacy of new technology enterprises. He enjoyed a clear advantage over Bush among voters who identified health care or social insurance as the most important issue shaping their vote, who saw improving education or strengthening Social Security as a high priority, and who preferred using the budget surplus to pay down the national debt and shore up Social Security rather than to reduce taxes. He was viewed as a moderate candidate and had an 8 percentage point lead

over Bush among moderate voters. He also made substantial headway among affluent and highly educated white women.

To be sure, Gore's "fighting" rhetoric was jarring—starkly at odds with the good times. A softer touch might well have gone down easier with middle-class voters. But I see little evidence that Gore moved to the left and paid a painful political price for it.

A final set of explanations centers on the candidates and their campaigns. Political scientists, including election forecasters, tend to downplay presidential campaigns. Since most citizens ordinarily pay little attention to politics and public affairs, campaigns are essential mainly in mobilizing fellow partisans and capitalizing on the broad forces that shape the context of elections. A sharp divergence in the quality of the candidates and the effectiveness of their campaigns in exploiting opportunities or overcoming limits set by that context can make a difference at the margin. But opposing presidential campaigns usually neutralize one another.

This theory was put to the test in 2000. The Bush campaign did an excellent job in portraying their candidate as an ideological moderate, blurring differences on issues with a natural Democratic advantage, reducing the perceived policy stakes in the election, and pressing a telling critique of Gore as an overbearing and untrustworthy candidate. After the Democratic convention and in the weeks leading up to the first debate, the Bush campaign appeared to falter. Gore, like Vice President Bush in 1988, closed a large deficit in the polls and moved into the lead by Labor Day. But unlike 1988, Gore surrendered his lead after the first debate and thereafter played catch up. The relentless critique of his debate performances reinforced the personal case Bush had been making against him, one that was consistent with the story line developed in the press.

Judged by the standards of such past presidents as George Bush, Jimmy Carter, and Richard Nixon, Gore's obvious shortcomings as a politician are not especially notable. But in the context of 2000, and in the wake of the master politician Bill Clinton, they might well have made a difference.

Sorting through these explanations for the infamous dead heat of 2000 will occupy scholars for years to come, though likely fewer than the quest to determine who "really" won the election. ■

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Technology and America Good Times

by Robert E. Litan

By any standard, the American economy has performed extraordinarily well during the past several years. Inflation has been low and relatively stable. The unemployment rate has hovered in the neighborhood of 4 percent, a level not seen in a generation. Most remarkably, however, labor productivity—the output of goods and services divided by hours of labor required to generate them—has grown at a 3 percent annual rate since 1995, a pace that, if continued, will allow a doubling in the living standard of the average American worker in just 25 years. This growth far outpaces the 1.4 percent annual rate recorded between 1973 and 1995 and is even higher than the roughly 2.5 percent growth rate achieved after the end of World War II up until 1973, a period dubbed by many economists as the “golden age” of American economic performance. What is especially remarkable about post-1995 productivity is that it has surged while labor markets have been tight, or precisely the time when economists otherwise would have expected growth to slow down as firms hire the least productive workers. Just the opposite has happened during this, the nation’s longest-ever expansion, which—although slowing at this writing—shows no signs of ending, despite recent turmoil in the Middle East and volatility in the capital markets.

Robert E. Litan, guest editor of this issue of the Brookings Review, is vice president and director of the Brookings Economic Studies program. He also holds the Cabot Family Chair in Economics at Brookings.

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Smart Transportation

by Robert Puentes

The United States has invested hundreds of billions of dollars building and maintaining roads to accommodate auto and truck travel. Yet no matter how much more money we spend, congestion and delays seem to get worse and political obstacles often put alternative strategies out of reach. Can the advanced technologies that are transforming American life solve our intractable traffic problems? A new universe of smarter vehicles and highways may be able to do what miles and miles of concrete and asphalt can't.

Intelligent Transportation Systems, or ITS, refers to the integrated application of modern technologies and management strategies in our surface transportation systems. Although in some ways ITS is nothing more than the natural evolution of venerable transportation technologies such as traffic signals and information displays, the widespread application of this new technology (helped along by government support) has already begun to transform the transportation network.

Public-sector ITS applications lessen the need to build more roads by using existing infrastructure more efficiently. For example, state transportation departments now operate dozens of traffic control centers nationwide. These \$20–30 million centers keep an eye on traffic by means of multiple often wall-size video images from cameras connected by miles of high-tech cable. As needed, workers dispatch emergency vehicles, adjust traffic signal timing, and relay road information to motorists.

Private-sector ITS includes in-vehicle devices to

help drivers find directions, avoid accidents, get information, and enhance safety. Talking navigation systems use the military's global positioning satellite technology and computerized maps to provide turn-by-turn directions for drivers in unfamiliar territory. Hertz is installing about 50,000 such systems in its rental car fleet. Individual consumer demand is steady but slow, partly because the systems are expensive. General Motors' closely related wireless OnStar system has more than 100,000 subscribers. OnStar uses cell phone technology to connect drivers with human operators for directions, concierge services, and emergency assistance.

Intelligent transportation has required a heavy investment, both private and public. Since 1990, the federal government, historically a key player in developing and redeveloping the surface transportation system, has spent more than \$1.3 billion, with another \$900 million obligated through 2002. Independent market research for consumer products suggests that the U.S. private-sector market for ITS could exceed \$300 billion over the next 15 years. Public-sector infrastructure costs over those 15 years are estimated at about \$75 billion. Anticipated benefits include better air quality, lowered fuel consumption, accident mitigation, and more efficient use of emergency services, as well as reduced travel time.

ITS "works" for the same reason electronic cash registers do—because automated technologies reduce operator error, can be tied together into a system, and provide instant feedback on system performance from a central

location. Until just a few years ago, surface transportation was the equivalent of the old push-button cash register and cashier. Today ITS is becoming the gleaming supermarket that speeds customers through check-out, enables them to pay electronically, dispenses information to help them make better decisions, and responds to a clean-up in Aisle 6 (or Highway 6, as the case may be).

Advanced transportation technologies are not stand-alone; they work within the existing transportation system. High-tech components by themselves will not go a long way in reducing congestion, pollution, or operating costs. Rather, it is the integration of devices, systems, and agencies that makes the difference. The investments made by Washington and the states have certainly been significant. And many studies have shown that when properly integrated, ITS does reduce the need to build new roadways and comes out positive in benefit-cost analyses.

ITS will not solve all transportation problems. Critics note that by making driving time more comfortable and convenient and by making trips more predictable, ITS can exacerbate congestion by facilitating the longer daily commutes associated with suburban sprawl. Indeed, as we move into the 21st century, our nation's roadways are still dangerous, congestion continues to escalate, and quality of life deteriorates. But by combining technological advances with the existing transportation system, we can build a network of smarter cars, smarter highways—and smarter travelers.

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Will this good fortune continue, or will the American economy lapse into the slower growth to which we had grown accustomed just a few short years ago—when Princeton economist Paul Krugman urged us all to have “diminished expectations”? To some degree, the answer will depend on how our newly elected president and members of Congress handle the projected surpluses in the federal budget. In particular, if the surplus materializes—that is, if the economy does not plunge into recession—but is spent too quickly, the Federal Reserve is likely to offset the fiscal stimulus with higher interest rates, which will discourage investment and thereby slow the future growth of productivity and living standards. By contrast, a prudent fiscal policy that preserves the surplus will help keep interest rates low, thereby continuing to lay the foundation for solid investment-led growth in the years ahead.

In the long run, however, almost certainly the most important factor driving improvements in productivity and living standards has been and will continue to be the rate of technological advance. Technology not only makes workers more productive but, in the health sciences, also enables them to live longer. Technology also shapes our society. Adults today cannot imagine a life without the automobile, electricity, or the air conditioner—three of the many 20th-century technological wonders they take for granted that were not widely available in their parents' generation. Similarly, our children certainly will be unable to imagine life without the computer, the Internet, and, when they grow old enough to realize its importance, the genetic revolution that is likely to prolong the life spans of the current and future generations.

As this nation welcomes a new set of leaders to political office, while ushering in a new century, it is timely and important to address the themes explored by the articles in this issue: how to keep the technology boom going and, in turn, how to respond to some of the vexing public policy issues that the Internet revolution in particular has raised.

Keep the Technology Boom Going

While new discoveries, new products, and industrial processes are typically invented and developed by the private sector, public policy plays an important role in encouraging innovative activity. Three key policy areas are addressed in this issue, and in each the authors either raise cause for concern or discuss new controversies that are best resolved sooner than later.

One important way in which the federal government, in particular, has stimulated technological advance is by funding basic research—often highly theoretical work that lays the scientific foundation for commercial applications down the road. Much of the information technology revolution—the hardware, the software, encryption techniques, artificial intelligence, and the Internet itself—owes its origins to federally funded research. A similar claim can be made for much of the commercial work that is now revolutionizing biotechnology.

Yet unlike applied and commercial R&D, whose benefits are largely captured by those who undertake it, basic research generally produces benefits that are later widely used, often in unanticipated ways. In the jargon of economics, basic R&D is a “public good” that, like such other public goods as national defense and a well-functioning legal system, will not be supplied to society’s fullest satisfaction without some degree of government support.

Supporting Basic Science

For much of the postwar period, driven by the nation’s rivalry with the Soviet Union, the federal government actively supported basic science, primarily in connection with military (and to a lesser extent, space-related) activities. Although this research has produced some welcome spin-offs—such as the Internet itself—the federal share in overall R&D has fallen since the end of the Cold War, understandably so. But as Linda Cohen and Roger Noll demonstrate, the government’s support of basic science—outside health—has become a smaller piece of the total research pie. It is tempting to dismiss this trend by pointing to

the explosive increase in venture capital funding for all kinds of new business undertakings, especially in information technology. But venture funding primarily supports applied or commercial R&D, boosting ideas whose origins often spring from earlier basic scientific discoveries. Cohen and Noll express concern that unless federal support for basic science, especially in math, engineering, and the physical sciences, grows substantially in the years ahead, the intellectual cupboard that has been feeding the entrepreneurial drive of the late 1990s may grow increasingly bare, with disturbing consequences for future business formation and economic growth.

Unfortunately, resolving the problem will take more than money. More scientific output will require more well-trained scientists. Yet on this count, Noll and Cohen report the disturbing fact that the numbers of American-born scientists and engineers have been static even as our population has grown. As a result, America increasingly has had to import foreign scientists, who although they make worthwhile contributions while they’re here, often return to their home countries (many of which are desperate to entice them back). The challenge for policymakers is to think long term: to support the training of a new generation of scientists, engineers, and mathematicians at the university level. Otherwise, throwing more money at basic science will simply drive up the salaries of existing professorial talent without necessarily generating new ideas in the process.

Patents and Competition

There is a tension between the next two policy instruments for stimulating private innovation. On the one hand, the Constitution guarantees inventors and developers of written material temporary monopolies—patents and copyrights, whose terms Congress may fix—to encourage the development of new ideas and works. Statutory and common law also protect trademarks and trade secrets for a similar reason.

On the other hand, the capitalist economic system rests on the virtues of competition to stimulate entrepre-

neurs not only to innovate, but also to cut costs, to stay a step ahead of the competition. The importance of competition has been enshrined in various antitrust laws, which give the government (both federal and state) the authority to stop mergers that may threaten competition and to halt business activities that frustrate competition, such as price fixing and other forms of collusive activity, as well as practices of dominant firms that are aimed at squashing competition and have little or no legitimate business justification.

How can the nation’s commitment to upholding intellectual property (IP) rights and competition—at the same time—be squared? Several articles in this issue wrestle with this question. At perhaps the simplest level, Jonathan Baker—a former antitrust enforcement official—argues that if IP rights are treated like any other property rights, there need be no conflict between the nation’s commitments to IP protection and antitrust. Holders of IP cannot merge with or cross-license each other to reduce competition in particular markets, while firms that earn monopoly positions fairly (by, among other things, exploiting the value of their intellectual property) nonetheless cannot be permitted to entrench their dominance by forcing consumers to deal exclusively with them (as Judge Thomas Jackson found Microsoft to have done). Subject to these constraints, however, holders of IP rights certainly have full ability to exploit them in most any way they see fit.

One of the hard questions, on which different views are expressed here, is how far policymakers should go in being willing to grant patents for certain kinds of innovation. Baker, as well as Cohen and Noll, expresses concern that the economic landscape is becoming littered with too many patents and copyrights, which make it difficult for new businesses, especially those seeking to use genetic information and certain business software, to enter markets unless they pay what can be hefty license fees to patent holders.

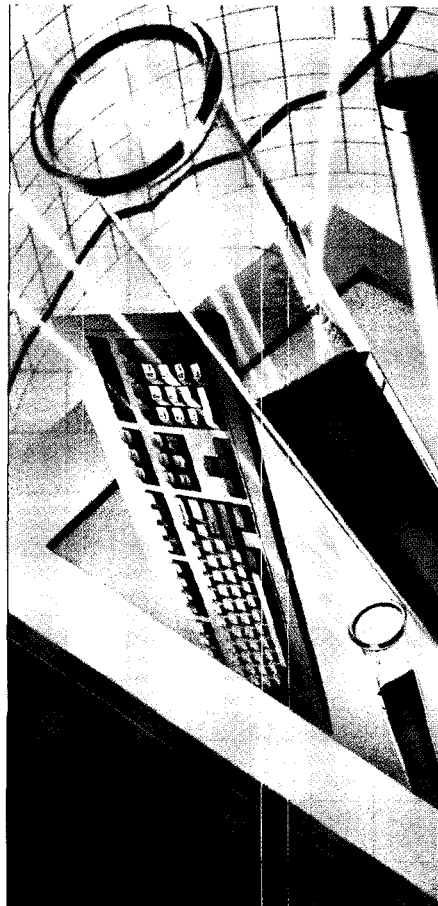
William Haseltine, the chairman of one of the nation’s leading biotechnology

companies, takes a different tack, at least with respect to patents for genetically based medicines. Haseltine argues that strong patent protection will be required in this field to reduce the risks of the massive and time-consuming investments that companies must make to continue to deliver the dramatic reductions in cost and the life-saving improvements that genetically based drugs are just beginning to provide. For similar reasons, price controls on such new pharmaceuticals can threaten the access of these companies to the investment funds required to support their research and development.

Technology and the Environment

On a different note, technological advance has been blamed in some quarters for leading to undesirable outcomes: the automobile and electricity generation plants, for example, are major sources of pollution. The challenge society faces is not, however, to halt such advances, but to find ways to “internalize” these environmental costs so that producers and consumers take full account of them when making investment and purchasing decisions. In fact, federal environmental regulators have been trying to do precisely that by adopting such market-like devices as emissions trading to reduce pollution in a cost-effective manner.

David Austin and Molly Macauley demonstrate in their article how such incentives can encourage technology to lend a helping hand to environmental cleanup. Automobiles emit far less pollution today than they did 20 years ago because they are equipped with catalytic converters, and, most recently, with sensors that are dramatically improving the efficiency of auto engines. Fuel cells hold the promise of reducing the emissions of carbon dioxide, thought to be the main culprit behind global warming. Satellite technology is being used to improve crop yield and health while reducing the need for environmentally harmful chemicals. In short, technological change should be viewed not necessarily as the source of new environmental problems, but as a solution to the problems we have today.



New Policy Challenges

Just as technology is changing the way we live, it is also creating a variety of new challenges for policymakers. Articles in the balance of this issue address some of the challenges that arise from the hottest new technology, the Internet.

Consider first the vexing, and closely related, issues of security and privacy. Public opinion polls consistently show that more people would use the Internet if they felt more comfortable that the personal information they provide on it is secure and if they were given a choice as to how that information later could be used or to whom it may be transferred. In principle, both concerns eventually should be allayed to some degree by technological advances in browsers and software. More privacy legislation may be in the offing as well.

Yet other security concerns associated with the Internet directly conflict with privacy, as Michael O’Neil highlights in his article. In particular, criminals are using encryption software to protect the security of their Internet transmissions, thereby avoiding the use of the telephone, which law enforcement officials can easily monitor with a

search warrant. The FBI has tried to level the playing field with plans to monitor e-mails and other web traffic through a remote “sniffing” device called “Carnivore”—a prospect that has aroused strong concerns about privacy and caused Attorney General Janet Reno to order a review of the whole idea. In the meantime, the government probably will have to intensify the use of its own hackers to try to crack encrypted messages sent by suspected criminals, while toughening penalties against those who deliberately plant viruses and disrupt Internet traffic.

Copyright and the Internet

A second set of policy issues spawned by the Internet—or more precisely, by the Napster software program developed by then 19-year-old Shawn Fanning—is how, if at all, to protect copyrights on the Internet. Napster is used by tens of millions of people in the United States and elsewhere around the world (probably including many readers of this magazine) to swap digital recordings. At this writing, the legal fate of Napster is unclear, with continued wrangling in the courts expected for some time. But the prospect that file-sharing technologies like Napster, of which there are now many, may allow unlimited copying not only of recordings, but also of videos, books, and software programs, has unleashed a highly contentious debate between those who see the technology as a boon to consumers (and also unstoppable) and those who view the technology as threatening the distribution of any kind of new, original content on the Internet.

Jonathan Band and Cary Sherman take opposing views on this subject in their articles. Band argues that recent legislation, coupled with new encryption or copy controls likely to be available soon, will provide content providers with overly broad copyright protection, inhibiting “fair uses” of recordings and other copyrighted works, to the detriment of libraries in particular. Sherman responds by defending the recording industry’s legal fight to prevent file-sharing programs from eroding the value of copyright and thereby reducing incentives for artists to compose and perform

music in the future. Similar logic would apply to other types of content capable of being distributed on the Internet. Both authors agree, however, that ultimately technology will solve the "Napster problem"—a "solution" that nonetheless cannot be guaranteed—although they differ on the desirability of that outcome.

The Digital Divide

The so-called digital divide and how to close it is yet another policy issue associated with the Internet. In fact, the growing popularity and usefulness of the Internet—as a way to learn, connect with other people, and purchase goods and services at lower cost or with greater convenience—is the reason many support a national commitment, backed with suitable policy instruments, to provide something akin to universal access to the Internet.

In 1996, Congress took a step in this direction by authorizing a national program for subsidizing Internet access for schools, hospitals, and libraries. But access at home is far less universal, on the order of 50 percent (and even lower in most other countries). Robert Crandall nonetheless takes a skeptical view of the need and appropriateness of the government doing more to subsidize ownership of hardware and regular Internet service for individuals (let alone broadband service, which is now taken by only 3 percent of all households). Prices of various Internet access devices (not just personal computers) have been falling like a rock, and they are now available for \$400 or less. Some providers now offer Internet access for free. To be sure, computer ownership and Internet access are substantially lower among African-American and Hispanic households than among white households, but once account is taken of income, location, household size, and some other demographic variables, Crandall finds that Internet usage in these households is not significantly lower than for other groups. The digital divide, he suggests, should close naturally, as incomes grow, market forces make Internet access even cheaper, and households more widely appreciate the value of having it.

Another issue closely related to the digital divide is making effective use of the Internet in the classroom. It is one thing for classrooms to be hooked up to the Internet—a goal that is nearly accomplished after four years of subsidy through the telephone rate system—but quite another for teachers to be able to use the new technology effectively in teaching students. Craig Cunningham notes that on this score, the nation has a long way to go. Most teachers are not equipped to make full use of the Internet, nor are their classroom materials yet fully taking advantage of the interactive nature of the medium. There are a few shining examples where computers and the Internet are being used with significant effect, but the nation has a long way to go, he argues, before this success is widely replicated.

Innovation and Economic Growth

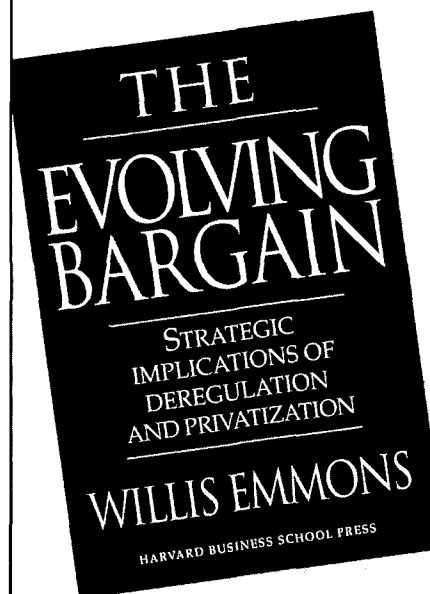
Technological advance is much like the proverbial goose that continues to lay the golden eggs of economic growth. But the process cannot and should not be taken for granted. Decisions policymakers take—to fund research, to grant IP rights, and to enforce the antitrust laws, among others—strongly influence the pace of technological advance and the form it takes. In turn, new technologies lead to new policy challenges.

In the concluding article in this issue, a research team from Harvard provides some survey evidence indicating that, on the whole, Americans are highly optimistic about the emergence of new technologies—especially new medical discoveries—and by large majorities believe that the benefits of scientific research outweigh any disadvantages. Similarly, most believe that the computer revolution has had a favorable impact on society—despite some of the downsides (concerns about privacy, availability of pornography on the Net, and security).

These views are not surprising. Technological advance means change, and change is not often a comforting experience. But it is primarily through continued innovation that living standards here and elsewhere are able to improve and thus to keep the good times rolling. ■

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Is U.S. Science Policy at Risk?

by Linda R. Cohen and Roger G. Noll

Although Washington cannot be said ever to have had a coherent technology policy, the United States has nevertheless done well compared with most nations in supporting and sustaining innovation. Since World War II the three primary elements of federal technology policy have been managing intellectual property rights, providing support for industrial R&D, and funding research and training in academic science and engineering. According to economic analysts, Washington's sustained efforts in these three areas have

generated a significant share of U.S. economic growth. But recent developments in each policy area—changes in property rights law, reductions in federal direct support for R&D, and a cutback in undergraduate science and engineering—pose worrisome questions for the U.S. research enterprise.

This essay focuses chiefly on trends in federal and private support for R&D, particularly changes in the standard “science indicators”—the share and composition of support for different categories of R&D. In some respects the evidence appears contradictory—and at first heartening. Although federal spend-

ing has fallen 18 percent in inflation-adjusted dollars since its peak in 1987, private spending has increased more than enough to offset this decline. But a closer look at the data reveals that changes in the science enterprise, particularly in the property rights regime and in the demand for scientists and engineers, call into question the reliability of these indicators. The raw data turn out to be misleading and provide little grounds for complacency.

What Do the Trends Tell Us?

Consistent with economists' findings that most economic benefits of R&D,

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NOE

Trends in Federal Support for R&D



especially fundamental research, do not and cannot accrue to those who perform it, a cornerstone of U.S. science policy has been that public support must be the dominant component in fundamental research and also play some role in industrial R&D. For the past half-century, Washington has thus paid for most university research, conducted fundamental research in national laboratories, and provided financial support for industrial research and development, especially in defense industries.

Both federal and state governments also provide R&D tax breaks, for example allowing businesses to deduct most R&D spending immediately rather than following a depreciation schedule. A federal research and experimentation tax credit also lets firms deduct part of

their incremental R&D expenditures from their taxes. In a recent NBER working paper, Bronwyn Hall and John van Reenan find that the R&E tax credit has had a substantial incentive effect; with each dollar of subsidy probably increasing private-sector R&D by about one dollar. The U.S. Office of Management and Budget estimates the "outlay equivalent" cost of the credit at \$2.23 billion in 1999—roughly 30 percent higher than it was during 1988-92, but still not enough to make up for the decline in direct federal support of industrial R&D, much less to account for the rise in private R&D.

Between 1989 and 1999 total U.S. real spending on research and development rose more than 36 percent. (All budget comparisons here are corrected

for inflation. Dollar amounts are reported in 1992 constant dollars.) R&D spending as a share of gross domestic product grew from 2.6 percent to 2.79 percent—higher than any year since 1967. (See box on data sources on page 13.) As figure 4 shows, private industry's share of R&D funding rose from about 50 percent in 1987 to more than 68 percent in 1999.

The declining federal share of R&D is directly related to the post-Cold War fall in defense spending. Direct federal R&D support to industry (mostly to defense industries) fell 50 percent between 1987 and 1999. But the Cold War's end did more than lower defense-related R&D. It also broke the political consensus in support of science R&D in general, thus shrinking the federal role

in fundamental research and dramatically redistributing R&D spending by disciplines and industrial applications.

In most fields of basic research, the federal presence is declining. Only in life science has federal support increased significantly. Total spending on basic research (see figure 2) rose more than 28 percent between 1991 and 1999, thanks largely to industry and universities. The federal increase was small—only \$2.2 billion—and of that, life sciences accounted for \$1.7 billion.

Although total federal academic spending has grown 55 percent since 1987, the federal share of academic research has been falling for 30 years and by 1999 was down to 57 percent. The share of federal support for university research going to life sciences grew from 58 percent in 1990 to an estimated 63 percent in 2000. Physical sciences, math and computer sciences, and engineering—traditionally fields whose research support has come mostly from Washington—have declined as a share of the federal academic budget from 27 percent to 24 percent. Although federal support for these activities grew, it did so slowly—less than 2 percent a year on average.

Industrial R&D has undergone similar changes in public and private support. In addition to changes in the public and private share of total R&D, the technological focus of R&D activities of the public and private sectors has diverged. Federal support for industry-performed R&D remains concentrated in defense areas such as missiles and aircraft

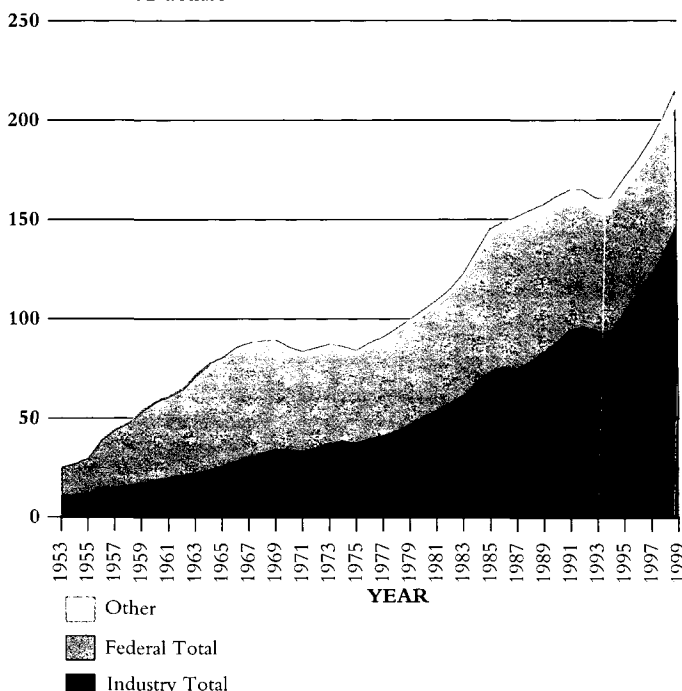
(44 percent), engineering services (14 percent), and scientific instruments (19 percent). By contrast, company-supported R&D in the late 1990s was directed toward information technology, including computing, electronics, communications equipment, and computing services (more than 40 percent); drugs and medicine (9 percent); transportation manufacturing (14 percent, of which only 4 percent is in aircraft and missiles); and scientific instruments (7 percent). Industry data for basic research spending are incomplete, but industry spending appears to be distributed broadly, with about 20 percent in drugs and medicine and the remainder scattered widely across the technical fields related to physical sciences.

Industrial R&D, which drives innovation in the private economy, is now spread relatively evenly among different fields and still emphasizes applications of the physical sciences and engineering. Washington, by contrast, concentrates its industrial R&D support on missiles and aircraft, in which industry now invests relatively little. And federal spending on fundamental research increasingly focuses on life sciences, which is the science base of neither the defense sector nor most of the industries where private R&D is growing rapidly.

Interpreting the Trends

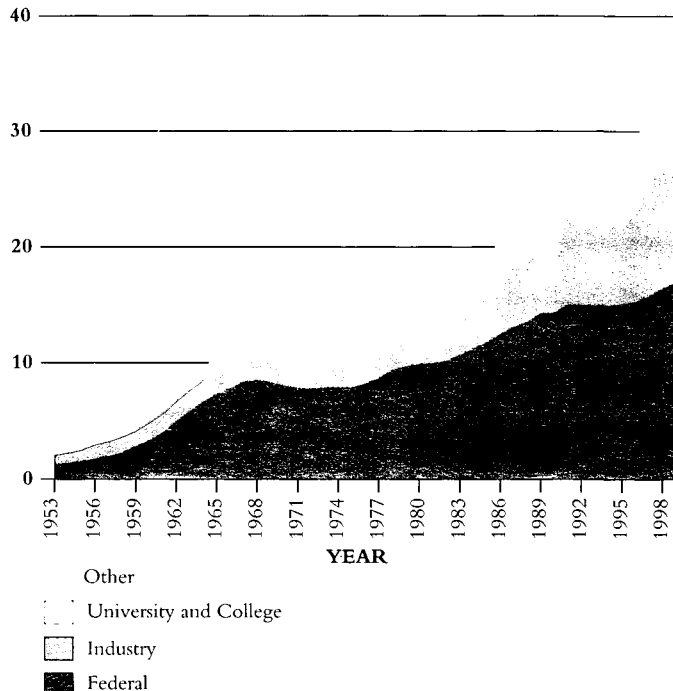
Although economic analysts have examined extensively the relationship between spending and innovation, their conclusions are not straightforward. Nor, for that matter, is the relationship.

Figure 1. U.S. R&D Expenditures, by Source
Billions of 1992 dollars



Source: National Science Foundation, *National Patterns of R&D Resources, 1999 Data Update*, and NSF, *National Patterns Historical Database*.

Figure 2. U.S. Basic Research, by Sponsor
Billions of 1992 dollars



Source: National Science Foundation, *National Patterns of R&D Resources, 1999 Data Update*, and NSF, *National Patterns Historical Database*.

DATA SOURCES

For the most recent data on R&D spending, see the National Science Foundation, *National Patterns of R&D Resources 1999 Data Update and Federal R&D Funding by Budget Function: Fiscal Years 1998–2000*. For data before 1992, see NSF, *National Patterns Historical Database*.

Details on academic spending by field, student enrollment, and the science and engineering work force are contained in the National Science Board, *Science and Engineering Indicators 2000*, and in the annual reports of the American Association for the Advancement of Science. Data here are drawn from the most recent report, *AAAS Report XXV: Research and Development FY 2001*.

For data on industrial R&D, see NSF's series, *R&D in Industry*. Preliminary data are now available for 1998, and more comprehensive statistics for 1997 and earlier.

For more information about S&E education, see Paul Romer, "Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers?" June 2000, NBER Working Paper W7723.

R&D is always risky, and even if it is successful, realizing its benefits can require long delays, complementary innovations, and even major changes in economic or social institutions. The National Science Foundation's authoritative R&D data series measure spending and employment in R&D at different times. For trends in the data to be meaningful indicators of innovation, the relationship between spending and innovation must be consistent over the years so that a dollar of R&D activity leads to roughly the same amount of innovation. But the changes in the R&D enterprise noted above, as well as changes in other R&D institutions, imply different relationships between spending and innovation and thus affect our interpretation of trends in R&D spending.

One seemingly simple issue is measurement. The NSF data on R&D spending in the private sector are based on a survey of firms, and for several reasons the way firms report R&D spending today may not be consistent with earlier responses. Firms may, for example, reclassify as research certain ongoing activities, such as market research and business software development, because increasing R&D spending enables them to claim a larger federal tax credit. With profits growing over the booming 1990s, firms are especially likely to reclassify more activity as R&D to maximize tax advantages.

And the R&D survey now includes many nonmanufacturing firms for which the traditional classifications of basic, applied, and development research have less

meaning. Whereas an auto maker's R&D is reasonably well defined and structurally separated from production, the distinction is much more ambiguous in the service sector. Arguably all spending by a software development firm could be R&D. Hence, data on both the level and composition of R&D effort are probably less reliable as R&D support shifts from the public to the private sector and, within the private sector, from manufacturing to services.

Recent moves to strengthen intellectual property rights law compound the problem. Since 1980, IP rights have been beefed up in several ways, such as by making genetic information and business software patentable and by cutting back "fair use" exceptions to copyright protection. Stronger intellectual property rights are likely to increase private R&D investment and innovation, in part because innovations may be more valuable to the inventor and in part because the acquisition of innovations by other firms may be more crippling.

Stronger IP protection can generate more R&D if it shifts some of the benefits of innovation to the innovator. U.S. patent applications and patent grants are now at record highs. The patent rate per dollar of R&D is higher than at any time since 1977. But the shift in the IP regime makes interpreting these numbers ambiguous for both the short run and the long run. The short-run problem is that R&D may be employed on projects with lower social payoffs on average, thus reducing the productivity of R&D. The long-

run problem is that even if stronger IP did not lower R&D productivity, overly broad IP rights could stifle the next wave of commercial innovations. For example, patents granted (as they have been) to discoveries of genes with no known commercial applications are essentially patents on basic scientific knowledge. Though that knowledge might be the basis for further useful research, the rights of the original patent

holder discourage future use of the gene.

Another reason why the productivity of R&D investment may be falling relates to the supply of skilled labor. If that supply is inelastic, an increase in private R&D spending would raise the salaries of science and engineering employees, rather than real R&D effort and hence innovative activity. Of course this response would require an external

change in the market, since generally employees' compensation is related to their marginal productivity—but an external event such as the change in the IP regime could, as noted, shift the private marginal productivity of scientists and engineers. Austan Goolsbee, in his article in the May 1999 *American Economic Review*, finds evidence in an analogous situation. He studied the labor market for researchers in the early

SCIENCE & ENGINEERING EDUCATION

Recent developments in higher education are eroding the long-run prospects for producing the workers needed to sustain an R&D-intensive economy. Virtually all growth in college attendance in the United States during the past 20 years has been in nontechnical fields. While the total number of bachelor's degrees rose about 15 percent between 1987 and 1996, the number of science and engineering degrees increased only in biological and social sciences. The number of bachelor's degrees in physical sciences, math, and computer sciences and engineering fell 20 percent.

Advanced degrees in science and engineering are on the rise—the number of master's degrees increased 20 percent from 1987 to 1996, and the number of doctoral degrees in science and engineer-

ing, excluding social sciences, increased more than 40 percent between 1987 and 1997—but only because of increased enrollment by foreign students. Since 1978 the share of foreigners in undergraduate schools in the United States has been constant at about 2 percent, but in science and engineering graduate programs, the share has doubled to roughly 30 percent. The number of U.S. citizens receiving doctoral degrees in science and engineering today is about the same as it was decades ago; the number receiving master's degrees in S&E has declined. And despite the growth in S&E graduate degrees, faculty positions remained roughly stable during the 1990s.

Are undergraduate enrollments in technical disciplines low because students are not interested or do not qualify? No. Stan-

ford economist Paul Romer argues that demand for technical education far exceeds the supply. And a wide range of evidence on enrollments, grading policies, graduation rates, student activities before college, and student interest bears him out. For example, among white students, who are less likely than minority students to experience poor preparation in high school, 21 percent of entering freshmen intend to major in S&E, yet only 13 percent do so.

Why would colleges and universities try to redirect undergraduate students from technical disciplines to the humanities? First, science and engineering education is generally more expensive, partly because S&E faculty have relatively high salaries (because universities must compete with the private sector for their services) and partly because technical education requires

expensive laboratories and equipment. Second, most higher education takes place in public institutions that are subsidized by state governments. State funding has not kept pace with enrollment, causing state universities to cut spending per student. Third, higher technical education is a joint product with research because many advanced undergraduates and graduate students learn by working in faculty laboratories, and in many areas of physical sciences and engineering, support for university research is stable or declining (the major exception is life sciences).

In short, universities are rationing slots in science and engineering classes, choking off about a third of the students who want to pursue these majors, and are expanding graduate education exclusively by admitting more foreign students. So

far most such students have remained in the United States, but increasing efforts by other nations to attract these students home could choke off the only part of the supply of technically trained workers that is still growing.

The long-run implication of these trends is pessimistic both for real R&D effort and for economic growth. Higher education is shifting bright students away from technical careers that create economic spillover benefits to society and toward careers without such spillover benefits, shrinking GDP in the process. Even if government were to try to encourage R&D by increasing funding, the primary effect would be to redistribute income to a fixed supply of scientists and engineers through higher wages rather than to advance technology and generate additional economic growth.

1980s, when the boost in federal support for defense R&D also supplied an external shock to the market for scientists and engineers, and concluded that most of the spending increase simply raised wages.

In fact, the supply of science and engineering labor has increased little for three decades. Colleges and universities are not meeting the demand of students who want to study science and engineering (see box). The most recent statistics show a small increase in the number of research workers, but only because of immigration. Not only is immigration politically controversial at home, but the recent U.S. success in attracting foreign scientists and engineers has led other countries to try to keep technically trained workers at home or to get them to return after completing their education.

Finally, the effect of the increase in industry spending depends on the relationship between private and public R&D. Is a one dollar increase in private funding equivalent to a one dollar fall in public funding? Few analysts think so. Some point out that federal R&D drives up the cost of scientists and engineers, so that reducing it enables industry dollars to buy more innovation, at least in the short run. Cuts in defense R&D and the exodus of scientists and engineers from the national laboratories probably spurred the private R&D expansion in the early 1990s, but these sources of labor are running dry. Others argue that public R&D so complements the private R&D effort that private R&D spending must overcompensate for the decline in federal support.

While economic research has failed to establish a clear relationship between private and public R&D expenditures in general, it does support the historical foundations of U.S. science policy with respect to foundational research: public research enhances private innovation, particularly in technologically related areas. This observation both underscores our concern about the divergence between public and private activities and questions the significance of the increase in private R&D spending.

In sum, the relationship between

spending and innovation is sensitive to the composition of R&D as well as to its institutional underpinnings and is fundamentally not comparable across R&D regimes. The apparent increase in R&D does not, over the long run, promise a comparable increase in innovation.

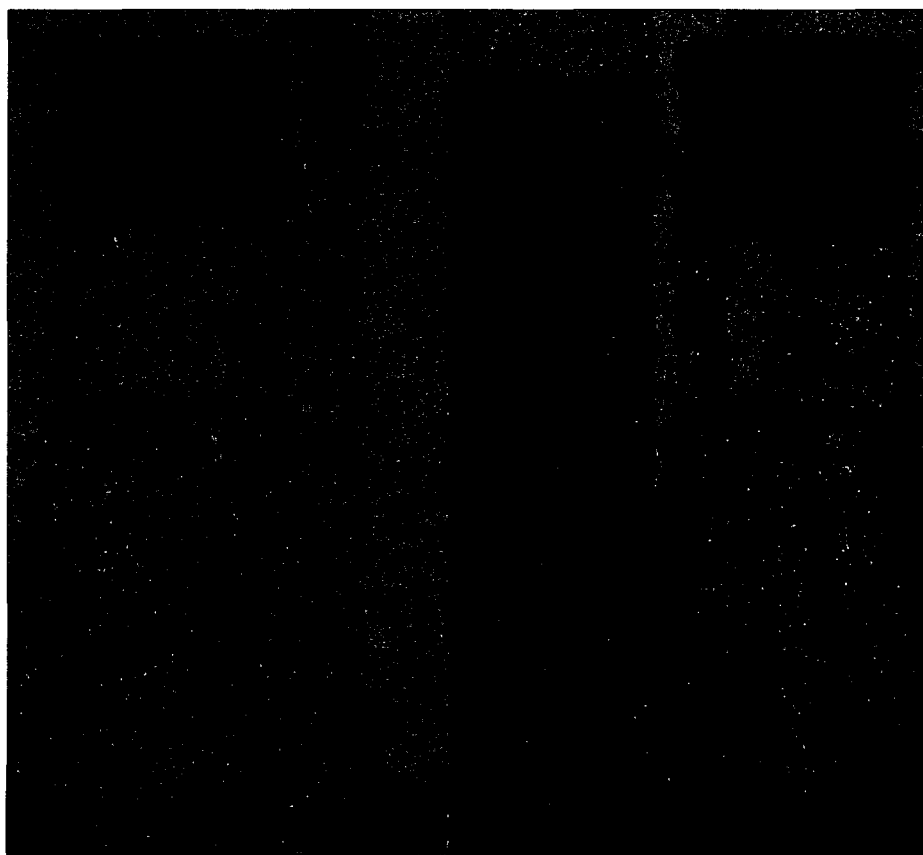
Implications for the Future

The 1990s have witnessed a return of optimism about the American economy. Unemployment is down. Strong economic growth has resumed. And measured private R&D spending is booming, suggesting that the foundations for future growth are in place.

So what is the problem? First, the federal government is a shrinking presence in R&D and is cutting back nearly everywhere except in biology and medicine. Second, the spending figures probably overstate the rise in private R&D spending, but even if private R&D has substituted for the fall in public spending, the private sector is less likely to support R&D that has broad spillover benefits throughout the economy. Third, bottlenecks in the higher education system and uncertain-

ties about the sustainability of immigration may restrain real R&D effort regardless of the spending propensities of both the public and private sectors. The long-run implication is slower technological progress and hence slower growth.

Our policy recommendations flow from these conclusions. First, federal spending on basic research should not be so heavily skewed to the life sciences, but should focus instead on areas of physical science and engineering that are more important to most of the economy, and to information technology in particular. Second, federal and state governments should expand higher education in science and engineering to accommodate would-be undergraduate majors. Finally, because the data on national R&D effort may be misleading about long-term trends and because the relationships among science indicators, the intellectual property regime, and innovation and growth are poorly understood, Washington should fund a major National Science Foundation research effort to get answers to these crucial questions. ■



A CAN Anti-KEEP UP?

AP/WIDE WORLD PHOTOS

Not since the 1911 breakup of the Standard Oil trust has a government antitrust case attracted as much public attention as the Justice Department's thus-far successful suit against high-tech giant Microsoft.

Although its ultimate outcome may not be known for several years, the Microsoft case has generated an intense nationwide debate among antitrust practitioners and business leaders about the relevance of antitrust to high technology. The critics' central claim is that the pace of change in high tech is so rapid that antitrust, and the legal machinery within which it must operate, is too slow and potentially counterproductive. Those who defend the applicability of antitrust to high-tech firms and industries, including the federal enforcement agencies, instead see a realistic potential for promoting innovation and consumer welfare through competition policy.

Jonathan B. Baker, of the American University Washington College of Law, was director of the Bureau of Economics of the Federal Trade Commission from 1995 to 1998.

Antitrust's contemporary engagement with high-tech markets, most visibly in the Microsoft case, is based on an emerging intellectual consensus about the way competition works in those markets. That consensus has been shaped importantly by two documents issued during the Clinton administration's first term—government antitrust guidelines on intellectual property licensing and a Federal Trade Commission staff report on competition policy in the high-tech global marketplace. The contemporary perspective on competition in high-tech markets is based on five core principles likely to withstand shifting political winds.

Intellectual Property

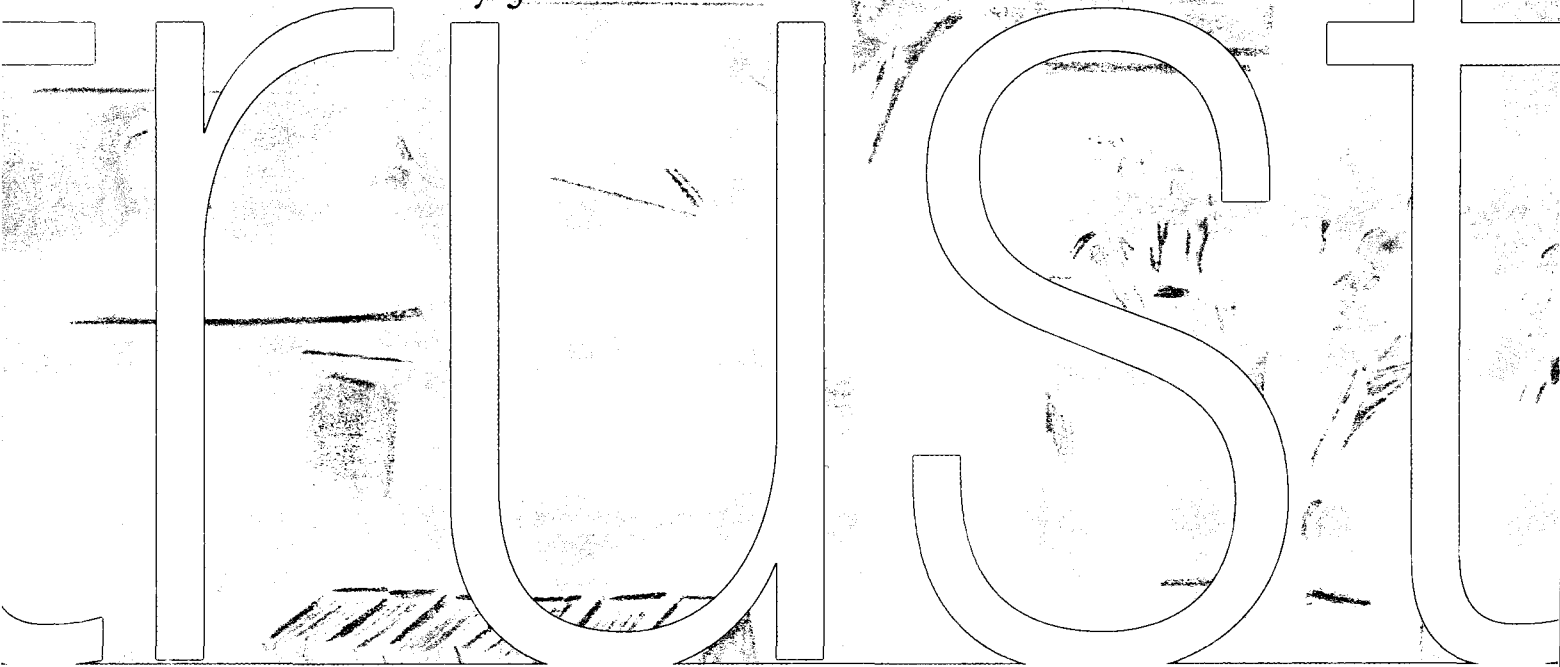
The first principle is that for antitrust purposes, intellectual property is just another form of property. A high-tech firm's patents and copyrights are no dif-

ferent from—indeed, are often more critical assets than—its physical property, its plant and equipment. That it may be easier to misappropriate many forms of intellectual property than to steal physical products is no reason to make intellectual property more or less suspect under the antitrust laws than any other form of property.

Consider mergers. If Coke were to acquire Pepsi or if United Airlines were to acquire American, the transaction would surely trigger an antitrust investigation, because the products and services sold by the acquired firm are likely important substitutes to customers of the acquiring firm. The analysis is similar when the key assets of the firms are rights conferred by the intellectual property laws. Federal enforcement agencies are routinely skeptical, for example, when a firm that owns the rights to one

Competition Policy in High-Tech Markets

by Jonathan B. Baker



drug for treating a disease seeks to acquire a firm with the rights to another drug with a similar use. Standard antitrust doctrines also apply to mergers among rivals in “innovation markets” in which a handful of identifiable firms engage in research and development on similar new products for the same buyers, even though no new products have yet been created.

This principle—intellectual property is just property—also applies to the antitrust review of intellectual property licensing arrangements. In a recent case, the FTC charged that two leading producers of the equipment used for laser vision correction, Summit and VISX, fixed prices under the guise of an agreement to share patents. This aspect of the case was settled in mid-1998, and the two firms recently announced substantial reductions in their per-procedure fees. Similarly, in 1997 the Justice Department worked with the video compression industry to structure a “patent pool” by which nine firms could share the twenty-seven patents needed to meet an international standard without risking harm to competition.

A firm can also sometimes harm competition by cutting off a past cus-

tomers. This was made clear by a 1951 Supreme Court case involving a newspaper monopolist faced with competition for advertising revenues from a newly established radio station. The newspaper violated the antitrust laws when it refused, for no legitimate reason, to do business with advertisers that bought commercial time on the radio station. Here too, antitrust enforcement makes no distinction between intellectual and other property. Thus, in a case settled in 1999, the FTC challenged Intel for cutting off access to technical information about upcoming Intel microprocessor products that customers needed to design complementary products like personal computers. The FTC argued that Intel harmed competition when it cut off its customers to gain leverage in unrelated commercial disputes involving the scope of competing intellectual property rights.

Competition and Innovation

The second principle, that competition promotes innovation, recognizes that firms have a powerful incentive to gain a march on their rivals by cutting costs or being first with new products or product improvements. The primary counter-

arguments, often associated with economist Joseph Schumpeter, are that a monopolist may have greater access to low-cost internal finance, and may be better able to take advantage of scale economies in research and development and to appropriate the full value of its new ideas. But the first two are potential advantages of all large firms, regardless of the extent to which they face competition. And the third, the monopolist’s possible advantage in appropriating the gains from innovation, could matter only when other means of assuring reasonable appropriability, such as intellectual property protection, are weak.

Moreover, the case for relying on patent monopolies rather than competition to generate new products and cost-saving process improvements now seems less potent than it once appeared. Innovation is a cumulative process. New ideas and new production processes are commonly refined and improved over time. Broad intellectual property rights can offer rich rewards to initial innovation, but they may well impede follow-on innovation. After all, the economic incentives to improve a patented idea or process are limited when the improvement can be used only in conjunction

with the original patent, as that improvement can be sold to only one buyer, the owner of the original patent. For this reason, a policy of fostering competition among owners of intellectual property could be justified solely in terms of its benefits in encouraging innovation, even ignoring consumer benefits from limiting the exercise of monopoly power.

This principle encourages antitrust enforcers to promote competition in high-tech markets with little concern that doing so will hurt the goose that lays golden eggs. Accordingly, for example, the FTC commonly negotiates curative divestitures when it believes that mergers threaten the loss of independent research streams aiming for new drug patents.

Network Effects

The third core principle is that network effects increase the concern with anti-competitive exclusion. Network effects (also termed network externalities or demand-side scale economies) are the value to a buyer when some other buyer also purchases the product or service. They are often especially important in communications. A telephone has little value if it can be used to call only a handful of numbers, but great value if everyone is on the network. Similarly, software programs for word processing or spreadsheets have greater value to a firm if its suppliers and customers use similar software and new employees need not be trained to use it.

Markets with strong network effects are frequently characterized by “tip-ping.” A firm that is expected to become dominant, perhaps after it achieves a small advantage in early competition, may find that new buyers disproportionately select its product. The market may quickly establish such a firm as the winner of what is effectively a standard-setting competition. Such competition is typically winner-take-most or winner-take-all. Once a market tips, it is harder for a rival to compete, even with a better product. To dislodge an industry leader may require a dramatically improved new product that “leapfrogs” the market leader’s technology.

When network effects are important, antitrust enforcers must move rapidly once they identify a competitive problem. Network effects also increase the concern with exclusion because they help ensure that the policies protecting rivals from unjustified exclusion will not reduce the pace of industry innovation. This point is relevant to understanding the procompetitive potential of government enforcement against Microsoft.

The district court judge, Thomas Penfield Jackson, found that Microsoft dominated the market for operating systems for Intel-based personal computers.

The contemporary perspective on antitrust supports the market by enlisting competition

Yet Netscape’s browser created potential competition for Microsoft’s Windows operating system, particularly when used in conjunction with Sun’s Java programming language. Netscape’s new product promised to make it possible for software developers to write applications programs that would access the operating system through the browser, and thus enable computer users to continue to use their favorite software after switching operating systems.

In response, according to the district court, Microsoft protected its market power in operating systems by limiting Netscape’s ability to market its browser through the two best channels for reaching computer users: as software installed with new computers or as the browser installed when signing up with leading Internet service providers like America Online. Microsoft kept Netscape’s browser off of new computers by convincing PC makers to prefer Microsoft’s own browser, Internet Explorer (IE), through exclusive contracts and by integrating IE into Windows. Microsoft also contracted for near-exclusivity with AOL and other Internet service providers. None of these exclusionary acts had an efficiency justification: Judge Jackson found that they were aimed purely at excluding Netscape and thus at preventing a long-term threat to the continued market power of Microsoft’s Windows operating system.

On the facts found by the district

court, antitrust enforcement has a strong potential for promoting innovation in operating systems (and in software, like browsers, that creates potential competition for operating systems). Preventing Microsoft from excluding actual and potential rivals by arbitrary means encourages software development by those rivals. Such support for new product development by Microsoft’s rivals probably means that the research and development effort rises industry-wide: Microsoft’s own incentives to innovate may be dulled, but only slightly. After all, the “prize” to Microsoft for successful

innovation—dominance of the new browser market and continued dominance in operating systems—remains extremely high because of the power of network effects. For similar reasons, tough antitrust enforcement against the unjustified exclusionary practices of dominant firms can be expected in general to promote innovation in winner-take-most high-tech markets, considering the collective incentives of the dominant firm and its rivals.

Judge Jackson’s decision upholding the government’s key monopolization charge follows from the legal rule that a monopolist violates the antitrust laws when it excludes rivals through conduct with no legitimate business justification. This rule permits a court to find an antitrust violation without need for a costly and time-consuming inquiry into harm to competition under circumstances in which competitive harm is likely. There is little danger of impeding industry innovation by applying this legal rule to the conduct of dominant firms in high-tech markets where network effects are important and innovation competition is winner-take-most. In contrast, Microsoft reads the relevant Supreme Court precedents differently, contending that proof of harm to competition is required and the company should win because, it claims, the government failed to make such proof.

This legal dispute, about the rules governing a high-tech monopolist’s

conduct, will now be refereed by an appeals court that, in an earlier decision involving Microsoft, questioned the application of antitrust laws to high-tech markets. The appeals court instead emphasized how hard it is for courts to determine whether new product designs harm or promote competition, as well as the danger of chilling dominant firm innovation by subjecting product integration to judicial review. Moreover, another federal appeals court with specialized jurisdiction over patent cases has recently announced, in a case involving Xerox's relationship with independent

sunk costs of entry, also making markets more competitive. For these reasons, the rapid information exchange made possible by the Internet will likely in general be a strongly competitive force, helping buyers obtain better and cheaper products.

But not always. Entry in the world of electronic commerce will not necessarily be as easy as going online to create a web site. The entrant must establish a reputation, both for high-quality products and for fair business practices. Furthermore, rapid information exchange could lead to higher-than-competitive prices if it gives sellers a better way to reach an anticom-

enforcement in high-tech markets the service of promoting innovation.

firms servicing its copiers, that a patent holder's refusal to license or sell its products was close to immune from antitrust liability, regardless of anticompetitive effect. Although that conclusion has not been reached by federal appeals courts with general jurisdiction, this decision too questions the emerging intellectual consensus on the way competition works in high-technology markets and the appropriate role for antitrust enforcement. In consequence, when these two legal disputes end up in the Supreme Court, as seems likely, their resolution may well have strong implications for the application of the antitrust laws to high-technology industries that go beyond the fortunes of the two firms, Microsoft and Xerox, or the software and copier industries.

Rapid Information Exchange

The fourth key principle underlying contemporary antitrust enforcement in high-tech markets is that rapid information exchange need not create a perfectly competitive marketplace. There is much to like in Bill Gates' powerful vision of "frictionless competition." What could be more procompetitive than the instant and universal exchange of enormous amounts of market and product information? Information exchange can dramatically reduce a buyer's transactions costs of search and help firms make better production and pricing decisions. In addition, Internet access and advertising could reduce the

petitive consensus on prices and market shares or if it makes it easy for price-fixing rivals to detect cheating on that consensus.

For these reasons, antitrust enforcers are taking a close look at business-to-business (B2B) marketplaces, to make sure that they are vehicles for lowering the transactions costs of exchange and not ways of fixing prices. They are also scrutinizing B2B exchanges to see whether they could be exploited by their members to obtain or preserve market power by keeping out entrants or aggressively competitive rivals. These concerns about exclusion may be greatest when most of the major firms in an industry own or control a B2B exchange (as opposed to merely participating in it). Widespread industry control of an exchange could also limit competition among B2B marketplaces by making it practically impossible for a rival B2B site, offering better or lower-cost services, to attract sellers and buyers. Notwithstanding these possibilities for anticompetitive mischief in the electronic marketplace, most B2B collaborations have strong potential for lowering costs of doing business and promoting competition, so will likely pass antitrust muster, many with little or no scrutiny by federal enforcers.

Business Conduct and Innovation

The final core principle shaping antitrust's perspective on competition in the high-tech sector is that most business conduct involving innovation by high-



Bill Gates

tech firms is procompetitive or competitively benign. To be sure, antitrust enforcers pay attention to emerging markets. When today's Old Economy industries like oil refining, steelmaking, and aluminum production were high-tech, they too were an appropriate focus for federal antitrust activity. But relative to the scope of high-tech markets in the economy, both yesterday and today, antitrust enforcement in the high-tech sector has been both measured and infrequent. Indeed, the antitrust enforcement agencies and the courts have long recognized the importance of innovation, the procompetitive benefits of most R&D collaborations, and the strong innovation record of many firms with large market shares. For every Microsoft, there are many other market leaders—like Cisco, Oracle, or Intel (which settled with the FTC)—whose market conduct does not seem to attract antitrust litigation. In short, the contemporary perspective on competition and antitrust enforcement in high-technology markets does not supplant the market. Rather, it supports the market by enlisting competition in the service of promoting innovation.

Antitrust is not dead in this high-tech age, nor should it be. Competition is vital to ensuring the continued rapid pace of innovation, and antitrust remains as essential as it always has been to preserving competition. ■

Geno

The
Path
Ahead
for
Science,
Medicine,
and
Society

omics

We are living in a time of breathtaking advances in our understanding of how the human body works. We are learning what makes us function at the most fundamental level: that of genes and the proteins they produce. Automated analytical equipment—much of it based on the same powerful capabilities that have given us desktop supercomputers—now makes it possible for a research group to accomplish in a few weeks what would a few years ago have been unimaginably time-consuming.

Until recently, a veil of mystery obscured the myriad biochemical mechanisms that control the cells making up our bodies. Physicians and scientists fighting disease could observe only relatively superficial changes in response to their treatments. Today, however, we have the tools to tease out the fundamental mechanisms involved in disease and to put that knowledge to use. However uncomfortable it might make some people, human beings are in fact extremely complex machines that can be understood. The veil is starting to lift.

As we learn how our molecular components work, we are also learning how to manufacture and manipulate them. Clinical researchers are discovering how to use human molecules—genes, proteins, and antibodies—as drugs. Dozens of such drugs have already successfully run the gauntlet of clinical trials and been approved for use: clotting factors for hemophiliacs, Epogen for anemia, and Enbrel for rheumatoid arthritis, to name just three. These and other biopharmaceuticals have increased life span and quality of life for patients with diseases as diverse as cancer, multiple sclerosis, and diabetes.

Such natural human substances are destined to overtake the small-molecule drugs that dominated late 20th-century medicine, in terms both of therapeutic power and of market share. Indeed, as the traditional pharmaceutical industry faces a serious but little-recognized crisis of productivity, the science of genomics, a new discipline that has captured most human genes in a useful form, is entering its full flowering. While the rate of discovery of conventional drugs declines, genomics is identifying a rapidly increasing number of possible biopharmaceuticals.

Over the coming decade these two intersecting trends promise a sea change in the practice of medicine that portends proportionate change in the pharmaceutical industry. Drugs will become more effective, and some key players in the biotechnology sector will become industrial powerhouses. Medicines that cure disease and greatly reduce the cost of care while providing many years of productive, active, healthy life will be developed,

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provided government policy, both in the United States and in other developed nations, supplies the necessary guarantees for protection of intellectual property and profit.

Regenerative Medicine and the Power of Biology

The reason biological molecules have such promise as medicine is that they can exert more subtle and proactive effects in the body than can conventional drugs. Whereas traditional drugs mostly work by inhibiting some cell constituent, a biological molecule can reprogram a cell, changing its activity and how it develops. By revealing the full range of natural biological molecules available for use as drugs, genomics has unlocked the potential tentatively demonstrated in the first phase of biotechnology more than a decade ago.

Last summer's triumphant declaration of victory by the projects aiming to sequence the human genome has drawn much popular interest, even though the job is not yet truly finished. And even when it is, this scientific achievement will be largely a distraction as far as the business community is concerned. A large segment of the pharmaceutical industry has had almost all human genes to work with for about the past five years, through collaborations with my company and others that have made headway in identifying genes. We found them by means of a technique that isolates the active genes without requiring us to know the genome sequence.

Successful programs to develop drugs based on genes isolated this way are well in hand. Products are being tested in patients. Progress is encouraging, especially compared with the record of genome sequencing. Some 97 percent of the genome consists of "junk DNA" whose function, if any, is not apparent. What is more, genes exist in genomic sequence in a fragmented state that makes it impossible to recognize those not already identified by other means. We know this, because several potentially medically important human genes that reside in a part of the genome that has now been sequenced were completely missed by the sequencing team. They admitted they could not find novel genes in the genome sequence. Sequencing the genome has been likened to a biological moonshot. It may be a scientific tour de force, but the near-term practical benefits are few. Drugs derived from human genes isolated in their useful form, however, are like communications satellites: perhaps less eye-catching, but of greater long-term value.

Other headlines have made clear that virus-based gene therapy is proving harder to develop than some commentators had supposed. There have been well-publicized setbacks, such as the death of a young man in Philadelphia attributed directly to a gene therapy trial. But viruses are used in only one possible type of gene therapy, and many genomics-based drugs will not be gene therapies at all. Therapeutic proteins and antibodies may well dominate the sector. Progress in these areas is real and rapid, in part because proteins and antibodies raise fewer toxicological issues than small-molecule pharmaceuticals.

Genomics, then, has already proved itself to be an immensely productive source of candidate drugs. It allows scientists to approach the search for therapies in a systematic fashion. Today's biotechnology products are only the first ripples of what will

within a few years be a tidal wave of innovative, health-extending genomics products. Now that most human genes have been identified, the next task is to discover what they do. New methods have been developed to greatly simplify this task.

Companies such as mine are systematically screening isolated genes with properties likely to be useful in treating specific diseases. Drugs derived from these genes will become the basis of what I call "regenerative medicine," a discipline that employs human substances to repair and restore damaged and worn-out tissues. Vaccines that fight and protect against cancer are another likely category of products, as scientists learn which genes misbehave in malignancy and devise strategies to counter them.

Genomics will also in time no doubt lead to the creation of much-improved small-molecule drugs, although these in general take longer to develop than biopharmaceuticals and are more susceptible to complications caused by drug interactions. For these reasons, it seems to me that biopharmaceuticals are where we will see the most remarkable medical progress over the next decade.

We hear a lot about how genetic research is likely to raise difficult societal issues, by providing disturbing predictions about who is likely to develop serious illness, for example. Such apprehensions are not groundless. We will indeed for some years to come be able to learn a lot about our genetic fate while having, in many cases, limited power to avert it. But this state of affairs stems from the aspect of genes that concerns why like begets like, from their role as determinants of inheritance. The future of medicine will, rather, emerge from genes considered as fundamental components of our anatomy that can control cells. Anatomic genomics holds the key to curing illness and repairing bodies.

The Next Waves

The reading public has in recent months been bombarded with dispatches not only about sequencing the genome and the travails of gene therapy, but also about experimental progress with stem cells. The practical implications of this progress do indeed seem to justify the attention being lavished on it, although many crucial questions are still being addressed. Researchers have isolated human stem cells that have a truly remarkable ability to transform into a wide variety of types. Moreover, cells with comparable flexibility may be obtainable from adult tissues. These discoveries will be synergistic with the use of human genes, proteins, and antibodies identified through anatomic genomics, and will constitute a second wave of regenerative medicine.

This second wave is already visible in outline. Physicians know now how to grow certain tissues for grafting, including skin, bladder, and cartilage, some of which are functioning in patients. Cultured cells have reportedly been used recently with some success in an experimental setting to treat stroke victims. It should be possible to use similar cells to treat a variety of disabling brain diseases.

Other types of cells have revealed newly promising potential for treating diabetes and liver failure. Genomics-derived drugs will vastly expand the range of treatments achievable with

human cells, because they will provide the ability to control how cells specialize and grow. They are also likely to alleviate a key problem in using stem cells: growing enough to meet the clinical demand. Many human genes give rise to signaling molecules that, properly deployed, can stimulate cells to divide. Although many potentially useful stem cells cannot easily be grown now in large quantities, there is no reason to believe this limitation will be permanent. Human proteins identified through genomics will be essential for increasing the supply of therapeutic cells.

A third wave of regenerative medicine will arise when researchers are able to use the key insight from the experiment that produced Dolly, the cloned sheep—the insight that it is possible to reset the genetic clock inside a cell. The Dolly researchers reset that clock by implanting a cell nucleus in an egg cell, and the achievement has now been repeated many times in different species. I am confident that before long someone will discover how to bring about this change without the need for egg cells. This will lead to production of replacement tissues that are younger, in the important biological sense, than those of the patient being treated, although they will be genetically derived from the patient and so incapable of provoking immune rejection. It seems unarguable that this advance has the potential to extend productive human life greatly. By the time this technology is well developed, neuromechanical prostheses are likely to be in widespread use too. They will be the fourth wave of regenerative medicine.

The Role of Government Policy

Despite the current difficulties besetting the pharmaceutical industry, biopharmaceuticals offer a bright future for scientific medicine. But part of that bright future depends on sound government policy—specifically, policy regarding patent protection and pricing.

If biopharmaceuticals are to be a vibrant business sector—and a rich source of better medicines—continued strong patent protection is essential. Companies that spend hundreds of millions of dollars to develop a medicine need the assurance of a patent that the drug will not quickly be copied. Indeed, the feature of strong patentability further distinguishes human genes, proteins, and antibodies from small-molecule drugs, which are relatively easy to mimic in “me-too” versions different enough to avoid infringing a patent and thus able to steal market share, slashing returns on the original developer’s investment.

Continued investment in pharmaceutical development also depends on sound government policy. Only one medicine in three, historically, has earned its development costs, and although I expect genomics to improve that record, the need for large clinical trials ensures that drug development will always be expensive. If genomics companies are to continue finding

investors willing to put funds into identifying and testing potent new gene-based pharmaceuticals, they must have confidence that the products of such expensive endeavors will not be subject to price controls. Controls on the prices of pharmaceuticals could be the surest way to undermine continued investment.

Price controls would assuredly limit the type and effectiveness of medicines available—without, in all likelihood, reducing the overall cost of illness. High-tech medicines, though expensive, can reduce total medical costs by cutting down on surgery and hospital and nursing home stays. They also improve people’s ability to work. One clot-busting drug for stroke, for example, saved an average of \$4,400 per patient by reducing the need for rehabilitation and home care. A study by R.L. Legg in *The Journal of Occupational and Environmental Medicine* showed that employers saved \$435 per employee per month with a new medicine for migraine that reduced absenteeism.

It should go without saying that science-based drugs have saved millions of lives and billions of dollars over recent decades.

A recent study prepared for the Biotechnology Industry Organization by Parexel International Medical Marketing Services, Inc., shows that each of 57 biotechnology drugs reduces the total health care cost of treating diseases of the elderly. Yet these very real benefits tend to get lost in the clamor over drug prices associated with the high costs of prescription medication not now covered by most insurance plans, while the high likelihood of further radical improvements in medicines seems often to be overlooked. Politically expedient price control regimes have squeezed most of the life out of the nascent European and Japanese biopharmaceutical industries.

What happened there could happen here if we let it.

Without question much needs to be done to improve access to pharmaceuticals, both domestically and internationally. In developed countries prescription drugs should be covered by insurance plans and by government-sponsored health programs, such as Medicare and Medicaid. Health benefits should be extended for everyone in the United States. We in the United States should work with international organizations to assure that all people, no matter where they may live, have access to basic, high-quality health care. A nation’s health care infrastructure, including access to effective medications, should assume a place of primary importance in developing countries, along with sound financial infrastructure and democratic institutions and physical infrastructure. The central challenge for health care policymakers is to broaden access without harming the biotechnology sector and so to bring the results of the genomics revolution to full fruition. It is within our grasp to turn the astounding technical progress of recent years into a medical legacy for the ages. Given the chance, the emerging breed of genomics-based biotechnology companies will do just that. ■

The central challenge for health care policymakers is to broaden access to pharmaceuticals without harming the biotechnology sector and so to bring the results of the genomics revolution to full fruition.

Technology as a Double-Edged Sword

Cutting through Environmental ISSUES

by David Austin and Molly K. Macauley

Slack covers everything. It sifts in everywhere. Slack is what doesn't melt in the mountains of red ore—a metal particle, powdered ore, powdered metal. It silts down all growing things. You can see the tiny bits of ore gleaming in your hands. The shining ore dusts your coat. It gets in your hair. On certain days they blow the slack out. Mighty currents of air blow the choking slack out of the costly mill chimneys onto the cheap human life outside. Those days the sun is darkened, and the steel workers returning home hide their faces as from a sand storm. They duck along, jackets over heads, under the fury of the falling slack. You find it everywhere. . . . Nothing, between soot and slack, can be clean long in the steel towns.

“Steel Towns,” from *Men and Steel*, by Mary Heaton Vorse

The Industrial Revolution brought forth extraordinary gains in financial prosperity. Between 1870 and 1910, per capita income in the United States rose almost 40 percent, and the value of manufacturing output increased sevenfold. Yet rapid industrialization left in its wake darkened noontime skies, noisy and unsafe machinery, and severely compromised living conditions.

It took nearly three generations before the first concerted efforts were made to bring pollution under control,

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but once begun, progress has been real. The air quality index for the United States now shows a 42 percent improvement since 1980. The number of U.S. cities failing to meet national air quality standards for ozone, 199 in 1990, was just 70 by 1995. Automobile emissions of six principal air pollutants have decreased 31 percent even while the number of vehicle miles driven has more than doubled.

Having dirtied the earth, air, and water for more than a century, technology is now showing promise in environmental cleanup. Technological innovations specifically aimed at reducing pollution—from cleaner manufacturing processes to flue gas scrubbers to cat-

alytic converters—now figure prominently in mitigating some of the growing pains of an increasingly technological world.

Technology, in other words, is a double-edged sword—one capable both of doing and undoing damage to environmental quality. In what follows, we look at technology and the environment in four key areas: energy, climate, water quality, and waste cleanup. In each case, we illustrate the dual nature of technology's environmental implications. We also touch on the emerging relationship between the Internet and environmental quality, one that again seems to cut both ways. We then note how technology is helping to fashion policies that allow producers and consumers to recognize and internalize the environmental costs of technology and thus to spur innovation to clean up the environment.

Energy

All the world's economies continue to face big challenges in using energy—the lifeblood of the industrial age—while maintaining environmental quality. Although U.S. energy efficiency is much greater than ever before, growth in the economy has assured rising energy consumption. While the average fuel efficiency of new passenger cars has more than doubled since 1975, the environmental gains are increasingly offset by the popularity of lower-mileage light-duty trucks and sport utility vehicles, increases in miles traveled per vehicle, and large increases in vehicle ownership.



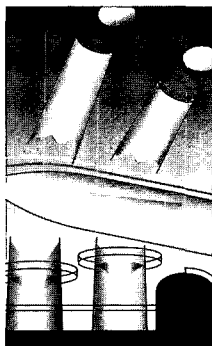
Nonetheless, technology—impelled by economic, regulatory, and environmental pressures—has made possible impressive reductions in vehicular emissions of volatile organic compounds and carbon monoxide per mile traveled. Reductions in both by 70–80 percent since 1977 would not have been possible without substantial innovations in, most notably, electronics. Here, the development of sensors that can closely calibrate energy use to demand has meant that both modern engines and industrial motors can be operated much more efficiently. Microcontrollers and digital signal processors also underpin a new generation of auto emissions sensors, which now consume up to 25 percent less energy. Modern autos have 20–90 of these sensors to control their engines precisely.

Climate

Discussions of energy use lead naturally to the question of how it may be affecting the earth's climate. In the United States, the energy sector accounts for more than 85 percent of total greenhouse gas emissions, with energy-related carbon dioxide alone responsible for about 80 percent. Most U.S. greenhouse gas emissions result from the use of coal and petroleum in electricity generation and transportation, respectively. But two newer technologies, fuel cells and small, single-cycle gas turbines—induced by economic and environmental considerations as well as by innovation policy—offer substantial environmental advantages over traditional, large, centralized power plants. Local generation by smaller plants can not only reduce transmission losses, but also improve air quality since they can be fueled by hydrogen and natural gas—much cleaner than coal on a per kilowatt hour basis. If fuel cells become widely adopted in transportation, emissions will plunge there too.

Adopting such technologies may not be a perfect solution, however, particularly in power generation. Some fuel cell

Technology will always be a double-edged sword, but creative use of new economic approaches to environmental management should help blunt its destructive edge and hone its capacity for good.



technologies release carbon dioxide, a greenhouse gas. In addition, small-scale plants serving only residential areas or small businesses may be less able to balance the peaks in demand than are larger plants serving both types of customers.

Water Quality

Air quality and climate change are the dominant, but not the only, environmental issues relating to energy use and production. Industrial and vehicular emissions, particularly of nitrogen oxides, are also detrimental to water quality. Nitrogen deposition acts as a fertilizer and promote the growth of algae in lakes, rivers, and estuaries, creating eutrophic conditions that kill submerged aquatic vegetation. In some places, such as the Chesapeake Bay,

eutrophication threatens commercial fishing as well as recreational pursuits.

Even more serious is the agricultural runoff of pesticides, fertilizer, and animal waste. Technology and policy are now beginning to address runoff pollution, but it is hard to measure, much less control, because it stems from widely scattered, “nonpoint” sources.

In the past few years, however, the tools of geographic information systems (GIS) using remotely sensed data have offered new ways to identify and observe these sources. The techniques combine land-use information with hydrology, topography, and soil data to make detailed, digitized maps at very fine scales and measure the potential for runoff. Remote sensing data on actual farming activities, collected by aircraft and satellites, can be combined with the digital maps to provide more accurate and timely monitoring and estimation of runoff. While it may not be possible to trace all the runoff to its original source, it is increasingly possible and cost-effective to trace much of it.

GIS tools have also fostered precision farm practices using real-time, comput-

erized, and detailed information about crop health. Remote sensors on harvesting equipment enable growers to discriminate among rows of crops for irrigating and for applying pesticides and fertilizer, thus increasing crop yields and reducing chemical use. And precision agriculture may have a bright future: information technology sales in the farm sector are now comparable to sales of farm equipment.

Remote sensing technology has also begun to improve the efficiency of municipal water use. Even in the United States, water is priced in a way that encourages wasteful consumption. The problem is compounded in many other countries, particularly in the developing world, because of a lack of infrastructure to meter water use. In Buenos Aires, for example, customers pay for water based on the size of their houses or apartments. The city has recently updated its real estate maps using remotely sensed data. Some hotels had been masquerading as studio apartments and were billed accordingly. While remote sensing has not replaced the need for metering, the new data have at least allowed the city to price water more accurately.

Despite their promise, even GIS and remote sensing technologies are “two-edged” in their environmental implications. The technologies raise some privacy concerns, for instance, that could lead polluters to cloak or hide their polluting activities, further inhibiting pollution monitoring and cleanup. Several legal cases concerning constitutional protections against warrantless searches have been motivated by the use of aerial photography for monitoring environmental compliance, and in more recent cases polluters had attempted to shield their actions from surveillance. Most recently, Midwest farming conglomerates have expressed concern about the public availability of aerial imagery if it is detailed enough to disclose farming practices. Such concerns could lead to curbs on the use of remote sensing for pollution monitoring and regulatory enforcement.

Waste Management

The trade-off between benefits and costs of new developments in biotech-

nology has made headlines in the case of genetically modified food supplies. Similar concerns surround the technology of bioremediation. Naturally occurring microorganisms have long been used to break down human, agricultural, industrial, and municipal organic wastes. Now, genetically engineered organisms are being used to treat not only industrial effluent, but also wastewater, contaminated soil, and petroleum spills. Bioremediation treats about 5–10 percent of all toxic chemicals and other hazardous waste; has successfully treated oil, gasoline, toluene, naphthalene, pentachlorophenol (a fungicide and wood preservative), and agricultural waste; and is being used at more than 30 munitions test areas across the United States.

Bioremediation can be a particularly cost-effective approach. Most of the costs of traditional cleanup technologies come in removing and disposing of contaminated soil, water, or other materials. Bioremediation requires only delivering the bacteria to the site, not excavating or otherwise disturbing it, thus reducing post-cleanup costs.

These benefits must be balanced against what some critics view as potentially large drawbacks. One concern is that bioremediation may largely immobilize rather than fully remediate contamination. Another is that instead of reverting to its original state, the site will be transformed in some unexpected way. A third concern is that the potential risks of adding genetically altered organisms to the environment, or even redistributing naturally occurring ones, may not be fully understood.

The Information Revolution

The revolution in information technology promises economic changes almost as great as those of the industrial revolution itself. Digital data storage, manipulation, and communication may not appear to have environmental implications, but some examples suggest otherwise. High-speed, high-bandwidth connectivity between our homes and offices may allow us to telecommute; it may also worsen sprawl around metropolitan areas if workers find it increasingly prac-

tical to live farther from their work. Whether online shopping replaces visits to the mall or takes place in addition to trips to the dentist and dry cleaners (trips that might have been combined with trips to the mall) will also shape the Internet's impact on auto travel. Packaging of e-commerce goods for shipping may be more materials- and energy-intensive than store-bought goods. Some controversial studies have even suggested that growth in demand for electricity, driven by new kinds of customers such as computer server warehouses, may have helped overload the electrical grid in northern California last summer. The net effect of new information technologies on energy consumption, land use, and travel has yet to be carefully studied.

From another perspective, as a tool for research and communication about the environment, the Internet appears to hold much promise. For research, it offers online bibliographic search engines, data archives and retrieval systems, rapid exchange of research results with distant colleagues, and software for scientific modeling of complex environmental processes. The Internet has also greatly expanded the public's access to and awareness of detailed environmental information.

Economic Incentives and Technological Innovation

Realizing the environmental promise of these and other new technologies—that is, exploiting the beneficial side of technology's dual nature—depends in part on “getting the prices right.” New technology will be better deployed to reduce environmental costs if these costs are recognized. For example, if automobile prices reflected all the environmental costs of tailpipe emissions, auto makers would have stronger incentives to use new pollution control technologies in new car models.

The “social costing” approach to environmental regulation has increasingly come into its own in the United States. For instance, tradable pollution permits—such as for sulfur dioxide emissions from coal-fired power plants—have created financial incentives

for electricity generators to adopt cleaner production processes. These market-based approaches can be more cost-effective than traditional emissions limits or technology standards, because firms that can reduce emissions most cheaply cut them more than they otherwise would—and then sell their excess permits to firms that cannot. At the same time, the market-based approaches induce innovations by putting a price on emissions and reductions.

The use of such incentive-based approaches is growing not only here, but abroad. International policy discussions on global climate change include taxes on carbon emissions and the use of marketable permits. Similar approaches to getting prices right in managing water quality and waste, as in our examples above, are likely to discourage environmentally harmful uses of these resources and further encourage use of new technologies in managing them.

Information technologies in particular will help expand the scope and effectiveness of incentive-based approaches, for at least four reasons. First, improved remote sensing technologies are making incentive-based regulations, which rely on emissions monitoring, either to enforce compliance or to levy taxes on pollution, more practical. Second, technological advances will help extend these approaches even to “smaller” polluters, possibly including small businesses and individual automobiles. Third, new information technologies are making it possible to fine-tune prices and regulatory programs—for example, by allowing pricing to reflect time of day, congestion, or atmospheric conditions. Finally, in the case of international resource management, remote sensing from space-based satellites may make it easier to monitor environmental compliance across countries.

From the steel towns of yesteryear to today's wired cities, the interplay of new technology and its environmental effects has indeed been complex. Technology will always be a double-edged sword, but creative use of new economic approaches to environmental management should help blunt its destructive edge and hone its capacity for good. ■

Cyber Dilemma

Internet regulation—from taxation to censorship—has been a legislative nonstarter in Washington. Yet change the name from regulation to cyber security and one finds an array of legislation that could affect web users in fundamental ways.

Internet security is of much greater concern to the government than to most Americans. Take Internet sabotage. What for many public officials—and some computer security experts as well—is a potentially ominous threat is, for many desk-bound office workers, merely a day's minor excitement. With the advent of each new e-mail-borne virus, firms shut down links to the outside world and wait. Within a few hours everyone is back on line, an anti-virus is in place, and a new cyber war story makes the rounds. Indeed, this pattern of spontaneous disruption has become so commonplace in today's computer-driven businesses that for many of us, it seems an acceptable cost of operating in the digital age.

Yet more than simple complacency is at work here. Popular resistance to greater government involvement in cyber security reflects the same tension that exists in the physical world. Americans certainly could minimize the likelihood of being victimized by robbers if they allowed the local sheriff to camp out in the living room, but for most of us, the resulting loss of privacy wouldn't be worth the marginal increase in security. The same holds true on the Internet. Along with its efficiency, Internet users clearly cherish the anonymity and privacy the new technology affords them. Many users fear that their privacy rights will be diminished if the FBI is out hunting for cyber crooks.

Protecting Critical Infrastructure

Critical infrastructure protection, as posited by the Clinton administration, involves enlisting the private companies that run the nation's energy, transportation, communication, water, and emergency services to help improve the security of the computer systems on which all rely. These services are critical,

the theory goes, because they are essential not only to our economy but also to national defense. They can therefore be targeted and, by virtue of their interconnectedness and low security, shut down—by spies, terrorists, hackers, criminals, or even disgruntled employees. Yet this hydra-headed threat hasn't materialized in such a spectacular way as to raise great public alarm and vindicate the government's warnings.

Attacks last February that shut down Yahoo, eBay, and other popular e-commerce sites demonstrated that our computers remain vulnerable and that the possibility of serious economic, if not security, harm does exist. But the only arrest to date suggests that a familiar kind of villain, a teenage computer phenom in his basement, may have been responsible for taking down at least one of the sites. So the threat that government officials worry about, the disabling or destruction of a major service infrastructure, still appears remote. The lack of any enduring damage appears once again to have calmed public fears.

New Technology, Familiar Challenges

The February attacks did get Congress's attention, eliciting several bills in both the House and the Senate to augment law enforcement capabilities to investigate and prosecute computer crime. At the heart of the legislation, and of the administration's plan for infrastructure assurance, is the proposition that the advance of digital communications and information networks has complicated the job of law enforcement—and by corollary that of intelligence agencies as well. But even if that proposition is accepted, privacy concerns will remain, if not grow.

The problem that best makes this case is encryption. No longer the sole province of governments and spies, effective, easy-to-use encryption allows any computer user to communicate and exchange information in a highly secure manner. In an age when vast amounts of personal data are stored in networks—and not at home or in bank vaults—encryption offers privacy protection that is increasingly important to many Americans. Yet their increased personal security may come at a price in apprehending criminals. Criminals and terrorists are now encoding communications and records using the same ubiqui-

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crime

Is It Possible to Guarantee Both Security and Privacy?

by Michael O'Neil

tous commercial encryption products. The FBI, the Drug Enforcement Administration, and other law enforcement agencies are hard pressed to break increasingly sophisticated codes used by wrongdoers.

The idea that technological innovations make it harder to catch crooks or spies is not new. The advent of the telephone also forced law enforcement to reexamine its investigative tools. Calls today for expanded cyber crime-fighting authority reveal a great deal about how the government views the challenges to law enforcement in the Digital Age. Sophisticated terrorists might take down the nation's electrical grid, so new security standards are necessary. The nation's telephone system is going digital, so major adjustments must be made to ensure law enforcement's continued ability to wiretap criminals and spies. Denial-of-service attacks against Internet businesses must be prevented, so the scope of existing computer crimes must be expanded to cover damages caused by loss of business.

All these changes can be useful additions to the electronic protections both industry and law enforcement need today. Yet the basis for their justification is also important, because of what it accepts as reasonable and what it will justify in the future. So is it true that technology has increased threats to the American way of life that must be countered by new government surveillance authority? And must government needs and personal privacy expectations be rebalanced?

These questions are hard to answer. Technology is advancing so swiftly that often we cannot perceive how it will affect our lives. In such a climate, it takes genuine prescience or unshakable convictions to know what a proper balance should be.

Take, for example, a key weapon in the government's arsenal against computer crime, the Electronic Communications Privacy Act. Enacted in 1986, it governs the protection of, as well as government access to, electronic communications such as e-mail. But in 1986, very few Americans understood the potential of either e-mail or the Internet. The idea that e-mail would greatly displace written and telephone communications between businesses, or even within a business, was entirely foreign. Perhaps as a result, despite the undeniably growing reliance of both businesses and individuals on e-mail, the legal protections afforded e-mail do not match those that apply to either paper records or telephone conversations.

Another government tool whose application to the Digital Age has raised concerns is the pen register, a device used to record the numbers dialed to begin a telephone conversation. Intercepting the actual conversation requires a warrant based on a high evidentiary showing. Obtaining the number dialed requires only the government's certification that the number is relevant to an ongoing criminal investigation. Amendments made in 1986 to the pen register law have been interpreted by the government to extend pen register orders to e-mail messages. Because there is no well-defined parallel between a telephone number and an e-mail address, applying pen register orders to e-mail has raised concerns about the ever-widening scope of government intrusion into Internet communications.

The debate about how to balance government and law enforcement needs with privacy expectations was given a high-

voltage jump start in June when it was revealed that the government is using a new Internet sniffing device to monitor web traffic. Called "Carnivore," the device is essentially a stand-alone computer installed at a key node in the system of an Internet service provider. It monitors all traffic carried over the system at that point and selects and stores communications the government is authorized to intercept—sometimes the full text, sometimes only the Internet address. The trouble is that Carnivore is a black box controlled by the government, its programming and selection criteria known only to those who operate it.

Carnivore gives government much more control than Ma Bell ever did. In the predigital age, the government presented its warrant or court order to the telephone company, which in turn routed the specified information to the government listening post. The FBI didn't attach the tap itself, and the common carrier was responsible to the court to ensure that the government got only what the court authorized. Carnivore changes that relationship and with it several independent checks on government action.

The government argues that these shifts in privacy protection are not intentional. It points out that Carnivore is used only by court order and only when an Internet service provider lacks diagnostic and monitoring capabilities to perform the surveillance ordered. Yet in partial recognition of the privacy issues raised by Carnivore, the attorney general recently ordered an independent review by a major university. In the same vein, the Clinton administration has suggested both a "clarification" of the pen register statute's application to the Internet and a requirement that a federal judge weigh the factual basis for a pen register's relevance to a criminal investigation.

The Debate in Congress

These steps are welcome news to personal privacy advocates, but the seriousness of cyber crime and critical infrastructure protection suggests that this debate is just beginning. The Clinton administration and Congress put forth a dizzying range of proposals, including new Internet surveillance provisions, Freedom of Information Act exemptions, regulation of commercial use of consumer information and, inevitably, the creation of a commission to study all the above. Though the 106th Congress did not enact comprehensive legislation affecting Internet privacy, cyber crime, and critical infrastructure protection, the new Congress will address these issues quickly.

What that Congress will take up seems clear enough. Yet unless it is guided by several basic principles, Congress risks addressing them inadequately and without balance.

The first category of issues to be addressed, law enforcement, encompasses two related goals. One reflects a bipartisan consensus to spend money on the problems du jour. In other words, expect Congress to allocate ever more resources for law enforcement to investigate and prosecute hackers and other cyber criminals. The other law enforcement effort likely will strengthen penalties for various computer crimes and expand government authority to police them.

The second category concerns continuing government efforts to get its own house in order. Specifically, look for

Congress to fund efforts by federal agencies to better protect their information systems. Most urgent is the shortage of highly trained information technology specialists within the government to protect critical networks, a need just now beginning to be addressed.

Third, Congress undoubtedly will move to protect individuals' privacy rights in the cyber world. In some cases, this step might involve simply applying the same standards from the physical world; in others, it might mean expanding protections to account for the public's growing reliance on electronic communication and record keeping.

Finally, expect Congress to try to create a better climate for information sharing between the government and the private sector, especially concerning threats and attacks on the nation's critical information infrastructure. Bills to accomplish this goal won widespread support in Congress and in industry this year, but fell victim to time.

Principles for Drafting New Laws

How Congress will resolve these matters is critical. Many factors will come into play, ranging from new technological developments to the political makeup of the next Congress and administration. Here are some suggestions as to how Congress, the executive, and the public should think about and work through these important and complex issues.

What is first required is a recognition that technology has changed the nature of individual privacy in fundamental ways. What the founding fathers sought to protect from unreasonable intrusion by the government—the privacy of a citizen's home and personal papers—is no longer found in the home or even on paper. Nowadays, our private information is as likely to be stored on computers, often computers that are part of a network, in electronic files, and often with third parties that many Americans either cannot identify or of whom they are unaware. Communications course through a much more diverse electronic medium than did telephone calls just a dozen years ago. This kind of change is likely to continue—and in ways not easily foreseeable to most of us.

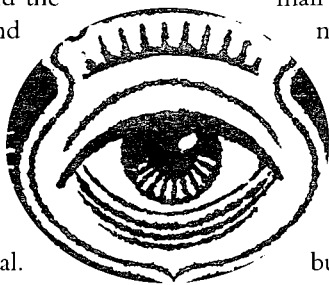
Second, the law, especially federal laws with national scope and application to the government itself, must adjust not only to changes in technology, but to the effect those changes clearly have had on the protection of individual privacy. This task will require dogged perseverance on the part of lawmakers. The law enforcement community will not easily cede surveillance capacity now or in the future. Its battle cry will be preservation, even improvement, of current capability in the face of ever more sophisticated cyber-criminal enterprise. After Congress passed the 1995 Communications Assistance to Law Enforcement Act to require common carriers to modify their equipment to permit government wiretapping of new digital telephone equipment, the industry spent years developing the necessary technical standards, only to have the Justice Department reject them on the grounds that more capabilities could

be, and therefore should be, included. When the Federal Communications Commission then largely approved the broad new requirements the Justice Department demanded, a federal appeals court had to point out that the balance between what was technically possible and the protections against unreasonable intrusion had not been struck. Congress had required just such a balancing test in the law, but had not reckoned with the tenacity shown by law enforcement in protecting and expanding its powers.

Third, there will be a great deal to get right the first time among all the issues that are likely to be addressed. For instance, "clarifying" how the pen register law applies to e-mail should make clear whether the subject line is more akin to a telephone number or to message content and to what extent an individual's Internet browsing must be disclosed. A Freedom of Information Act exemption for sharing cyber security information with the government should encourage information sharing not just with law enforcement agencies but between other parts of the government and among private-sector entities. And making computer crime laws tougher should not discourage prosecution, as current juvenile sentencing guidelines do. In the area of commercial privacy protection, a host of issues must be addressed, fleshing out just what notice, disclosure, and consent mean.

Fourth, there is much that neither Congress nor a new administration should try to do. In the area of critical infrastructure protection, cyber security should be improved through voluntary, private-sector-organized mechanisms. This will frustrate some in government, particularly at those times when fresh cyber attacks appear to threaten our use of Internet services. Yet the networks at risk, and the essential service industries they support, are largely designed, built, operated, and maintained by the businesses that own them. To be effective, critical infrastructure protection policy cannot be dictated by government, especially given the government's admitted failure thus far to improve security within its own ranks. Private-sector solutions, not public regulations, are most likely to work best for industry and, ultimately, consumers.

Finally, to return to the point on which I began, the national debate on new cyber law must avoid the dangers of label oversimplification. All the issues discussed above can be grouped together under the rubric of privacy protection. Yet, in the case of cyber crime initiatives, real care will have to be taken to achieve even modest gains in privacy protection. And ensuring effective personal privacy in commercial use of the Internet may well hinge more on better uses of the same software technologies that created the threat in the first place than on new federal laws. Thus, calling what we are doing by its real name—Internet surveillance or increased wiretapping powers in the case of some cyber crime provisions—may be the best way to deal both with the advance of technology and with protecting what remains of our electronic privacy. ■



**Technology
has changed
the nature
of individual
privacy in
fundamental
ways.**



he Internet has given rise to a puzzling copyright paradox. To hear the recording industry tell it, the copyright world as we know it is coming to an end. Between Gnutella and Napster-like sites, fans can easily exchange music files over the Internet, sending CD sales plummeting. Copyright law is powerless to halt the onslaught of Internet piracy, which will soon remove any economic incentive for creative activity.

Jonathan Band is a partner in the Washington, D.C., office of Morrison and Foerster LLP. He represents the American Library Association and software and Internet companies with respect to some of the matters discussed in this article. The views expressed, however, are his own.

THE Copyright Paradox

Fighting Content Piracy in the Digital Era

by Jonathan Band



At the same time, libraries, universities, and content user groups, voicing their helplessness before ever-strengthening copyright legal protections, insist that the content provider community is better positioned than ever to eliminate traditional user privileges. Historically, for example, the fair use doctrine has allowed academic users to reproduce without payment parts of copyrighted works for purposes such as criticism and classroom use. But, say these users, the new Uniform Computer Information Transactions Act (UCITA), adopted by the National Conference of Commissioners on Uniform State Laws in 1999, and the technological measures protected by the 1998 Digital Millennium Copyright Act (DMCA) will soon enable content providers to create the “pay-per-use” environment they have long sought.

Who's Right?

At first blush, it would seem that the content providers and the content

users—the Recording Industry Association of America and the libraries and universities (hereafter the library community)—can't both be right. We can't possibly be living in both the best of times and the worst of times for copyright protection. One of these two communities must be exaggerating.

Indeed, the available facts suggest that the recording industry may be overstating the harm caused by Napster and Gnutella. Although CD sales in record stores near university campuses have fallen (college students are among the biggest users of Napster and Gnutella), CD sales overall have grown 8 percent since last year. The group 'N Sync recently broke the one-week record for CD sales, ringing up more than 2.5 million. Beyond these hard numbers, anecdotal evidence suggests that people sample music on Napster and then buy the higher-quality CD if they like what they hear. So Napster-like sites may actually spur CD sales.

Moreover, the content community seems to be on a winning streak. The

recording industry secured a preliminary injunction against Napster (at this writing, the injunction was stayed pending appeal). A judge imposed the largest amount of statutory damages in copyright history—more than \$100 million—on MP3.com. The major sports leagues shut down IcraveTV. And the motion picture studios won an injunction against DeCSS, software that unlocks the encryption protecting DVDs.

Still, there is no question that the Internet facilitates piracy by allowing the widespread dissemination of lawful copies with no degradation in quality. Further, technologies like Gnutella do not require a central server, as does Napster or a typical pirate web site, making it hard to detect infringers. In short, the Internet does seem to pose an increasing threat to providers of copyrighted content.

At the same time, technological measures like encryption or copy controls encoded in software will prevent a teacher from making digital copies of an article for classroom use, and the DMCA has banned devices that enable

users to circumvent such measures. The net effect will be less fair use, and the de facto extension of the copyright term, as works remain technologically protected long after the copyright expires. (This assumes, of course, that the DMCA will survive the constitutional challenges now being mounted against it.)

Similarly, UCITA validates the enforceability of shrink-wrap licenses (which appear on software packages) and click-on licenses (which appear on screen and which users must click to install software or access a web site) and will accelerate their use to prohibit fair use by contract. The circuit courts are split as to whether such license terms are preempted by federal law, and it may take years for the Supreme Court to resolve the issue. And if the Supreme Court decides that federal law does not preempt such license terms, licensees will be at the mercy of the licensors.

quacy of existing laws, but the high cost of enforcing any law against the large universe of infringers. Each of the hundreds of millions of computers attached to the Internet is a potential distributor of unlawful copies. Although of limited use against this large universe of potential individual pirates, the new legislation ensnares the libraries—the most public of our institutions.

The following examples demonstrate the disparate impact of UCITA and the DMCA. A software firm markets a CD-ROM subject to a shrink-wrap license that prohibits the further distribution of the CD-ROM or its contents. If a consumer acquires the CD-ROM, copies it onto his hard drive, and e-mails it to a dozen friends, the publisher is unlikely to find out about the breach of contract, much less prosecute it. If, however, a library acquires the CD-ROM and lends it out in accordance with copyright's first-sale doctrine, the publisher almost certainly will sue the library for

In short, libraries (and other high-profile entities such as universities and large corporations) are likely to obey the laws and contractual terms that apply to them because they are law-abiding institutions and because they know they probably would be sued if they did not follow the law. In contrast, individual infringers are not likely to obey the law because they are not law-abiding and because they know they are unlikely to get caught. Seen in this light, the copyright paradox makes sense. Because the new laws do not meaningfully address Internet piracy, the content community remains vulnerable to piracy, but libraries are kept from engaging in historic library activities. The new laws also interfere with legitimate corporate activities. UCITA, for example, allows a software company to prohibit a business from selling copies of software when it sells a subsidiary even though copyright's first-sale doctrine permits the transfer.

The content community fears too little copyright protection; the library community fears too much. How can this be?

Which brings us back to the copyright paradox: both the content community and the library community appear to have legitimate, yet opposite, concerns about the future of copyright in the digital era. The content community fears too little protection, the library community too much. How can this be?

Of Ends and Means

The paradox is rooted in a mismatch between the stated ends of the content community and the means employed to reach them. The content industries have responded to the threat of Internet piracy by pushing for more legislation, such as the DMCA and UCITA. But although new legislation is the most expedient response to the threats posed by new technologies, it probably will not hinder Internet piracy because the problem with piracy is not the inade-

quacy of existing laws, but the high cost of enforcing any law against the large universe of infringers. Each of the hundreds of millions of computers attached to the Internet is a potential distributor of unlawful copies. Although of limited use against this large universe of potential individual pirates, the new legislation ensnares the libraries—the most public of our institutions.

Similarly, the DMCA probably would not discourage a college student from finding a circumvention utility somewhere on the Internet and using it to elude the technological protection on his favorite CD so that he could make the sound recordings on it available to his friends. But the DMCA would prevent a library from acquiring the utility through legitimate channels to make a preservation copy permitted under Section 108 of the Copyright Act. The DMCA flatly bans almost all circumvention devices, even those capable of noninfringing uses. Put differently, the DMCA would do little to deter unlawful conduct, but much to deter conduct that is otherwise lawful.

The logical next question is whether this discontinuity between means and ends, and the resultant collateral damage, is inadvertent or intentional. The charitable view is that the content community really believes that this legislation will help reduce piracy and has no intention of stifling library and educational activities. A more cynical perspective is that the content community pursued this legislation in part because it allowed the rollback of fair use, first-sale, and other user privileges the content community has always opposed. Indeed, conspiracy theorists believe that the libraries were the real target of the legislation, and Internet piracy served as a convenient pretext. Although generally I am not a conspiracy theorist, I am reminded of the following aphorism: "Just because you're paranoid doesn't mean they're not out to get you." ■

Music

on the

A New World Is Waiting

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Still, the threats posed by illegal distribution on the Internet are real and potentially devastating to any company that contemplates legitimate distribution of music online. To help ensure that a legitimate online music marketplace can take root and realize its full potential, the record industry has educated consumers about copyright online, policed the Internet for infringing activity, litigated where necessary to enforce rights under established copyright law, and worked proactively with technology companies to create new delivery mechanisms and develop open technological standards to protect digitized music.

Education, Enforcement, and Litigation

From the start, consumer use of the Internet has challenged traditional practices and value propositions in the music industry. The initial explosion of Internet sites offering illicit MP3 files of copyrighted music led consumers to think that music is free for the taking, along with everything else on the Internet. Surveys and focus groups revealed that consumers had no idea that they were infringing anyone's copyright when they downloaded popular recordings.

In response, the record industry launched an educational initiative—www.soundbyting.com—aimed particularly at universities, where Internet access was greatest, to educate a new generation of students (and administrators) about copyright law and the rights and wrongs of music use online. And to counter the unfortunate implication of Internet piracy that the music created by artists, songwriters, and producers has no real value, artists and record companies have launched a campaign to get consumers thinking about the true value of music.

Also in response to online piracy, the Recording Industry Association of America began to monitor the Internet for infringing sound recordings and to take action to close down illegal sites. The RIAA's Internet enforcement program is not expected to eliminate piracy: there will always be those who steal copyrighted works. Rather, the

goal is to create an environment in which a legitimate marketplace can exist because of the benefits it offers over the pirate marketplace.

A necessary component of such a strategy is litigation to enforce copyright rights on the Internet, especially against companies building businesses based on the unauthorized use of copyrighted music they neither own nor license. The recording industry has pursued litigation strategically to establish the principle that licenses are required for the commercial use of copyrighted music on the Internet.

Contrary to popular impression, record companies believe that existing copyright law provides an adequate framework to obtain relief against those who disregard copyright principles. New legislation, at least at this point, does not seem necessary, so long as the courts apply to businesses online the "traditional" copyright principles long applicable to businesses offline.

The major record companies have filed lawsuits against companies such as Napster, MP3.com, Scour, and MP3 Board.com—all cases where a business or service is built on unauthorized use of other people's copyrighted works. Napster, a so-called "file-sharing" service, illustrates why litigation is often necessary. Left unchallenged, Napster could have foreclosed the opportunities for a legitimate marketplace. Even if record companies launched Internet subscription services tomorrow offering access to millions of songs, why would a consumer pay for such a subscription service when Napster's service is free?

The federal district court in San Francisco agreed with that reasoning, finding that Napster is actively facilitating widespread copyright infringement and, in doing so, directly affecting the legitimate market for copyrighted works. Napster countered that its users are merely engaging in fair use by sharing files within the Napster network. But while the fair use doctrine requires a complicated and fact-specific analysis, one needn't be a copyright lawyer to know that sharing copyrighted music on a CD with millions of anonymous strangers on the Internet is not fair use.

The purpose of fair use is not to provide a catchall defense for widespread online infringement.

The recording industry will continue to rely on existing copyright law to establish that the rights of sound recording copyright owners apply online as well as offline. The hope is that, after establishing this principle in early litigation, it will not be necessary to argue these issues in court repeatedly.

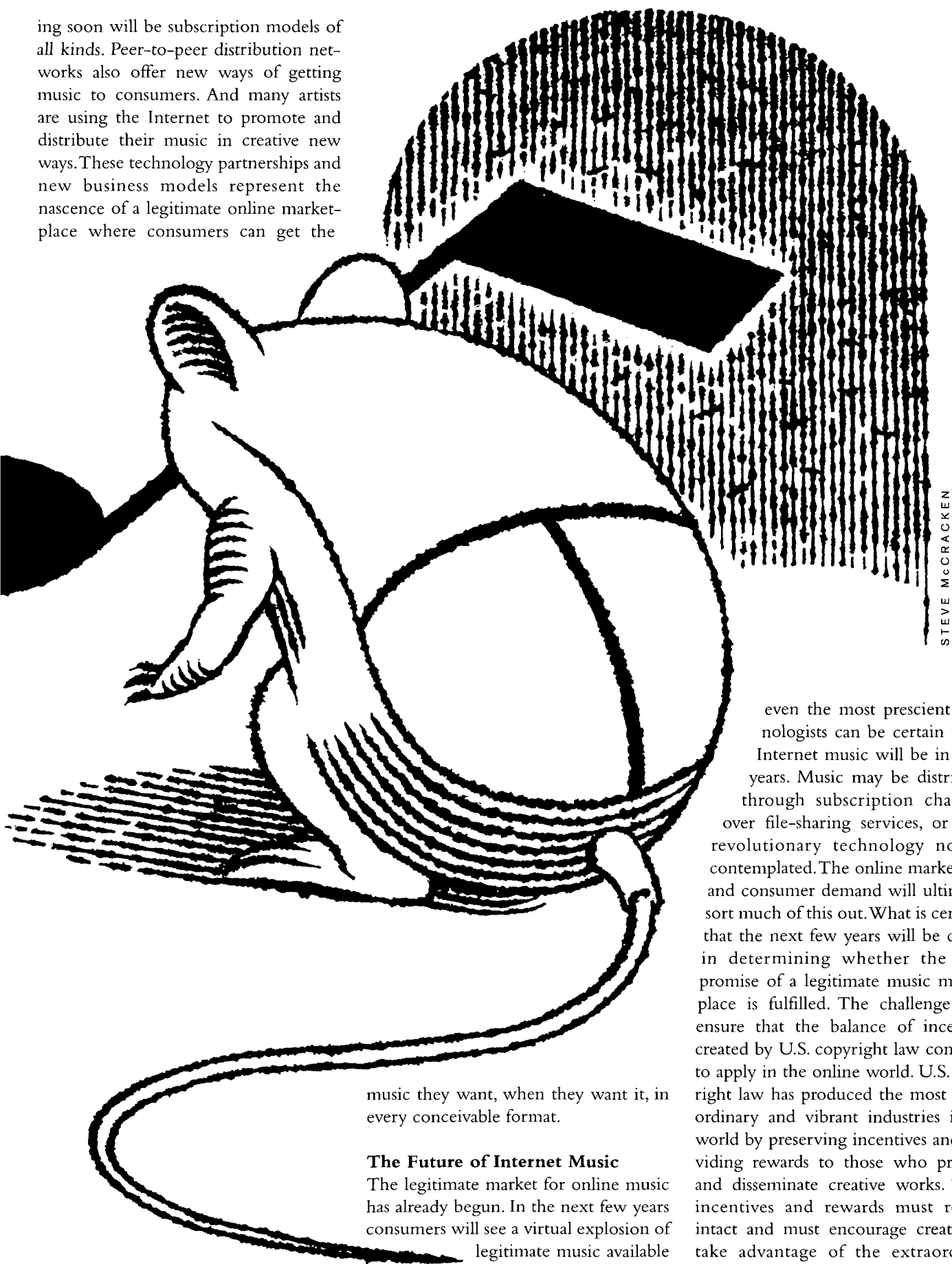
Technology Solutions

Litigation is not a business strategy. Ultimately the best response to online piracy is a legitimate alternative. The record industry understands that it has to make it easy for the customer to find and buy music online, and record companies are working to develop technology standards to protect digitized music as well as forming partnerships with technology companies.

As part of this effort, the record industry launched and actively participates in the Secure Digital Music Initiative, a consortium of some 200 companies representing a wide spectrum of technology and content companies including information technology, consumer electronics, Internet service providers, and security technology companies. SDMI is working to develop an open, voluntary technical framework for protecting music online. A widely accepted technical standard can enable artists and recording and technology companies to develop sophisticated new business models for the delivery of music. The technical framework developed by the companies involved in SDMI will encourage more companies to make music available on the Internet, creating a more comprehensive selection of legitimate music available for the consumer.

Individual record companies are also working with technology companies to develop new ways to deliver music content to the consumer. Many record labels already offer music downloads, custom compilations, and radio-style webcasts, interactive webcasts, and access to music stored in cyber-lockers. And this is just the tip of the iceberg. Com-

ing soon will be subscription models of all kinds. Peer-to-peer distribution networks also offer new ways of getting music to consumers. And many artists are using the Internet to promote and distribute their music in creative new ways. These technology partnerships and new business models represent the nascence of a legitimate online marketplace where consumers can get the



music they want, when they want it, in every conceivable format.

The Future of Internet Music

The legitimate market for online music has already begun. In the next few years consumers will see a virtual explosion of legitimate music available on the Internet. But not

even the most prescient technologists can be certain where Internet music will be in a few years. Music may be distributed through subscription channels, over file-sharing services, or via a revolutionary technology not yet contemplated. The online marketplace and consumer demand will ultimately sort much of this out. What is certain is that the next few years will be critical in determining whether the great promise of a legitimate music marketplace is fulfilled. The challenge is to ensure that the balance of incentives created by U.S. copyright law continues to apply in the online world. U.S. copyright law has produced the most extraordinary and vibrant industries in the world by preserving incentives and providing rewards to those who produce and disseminate creative works. Those incentives and rewards must remain intact and must encourage creators to take advantage of the extraordinary promise of the Internet. ■



THE
DIGITAL

DIVIDE

Bridging the Divide Naturally

by Robert W. Crandall

Now that telephone service is virtually ubiquitous, the new worry is that not all households are using these connections in a digital mode—that is, to connect to the Internet. Given the Internet's recent vintage and, until the past year or two, the relatively high cost of personal computers, it should surprise no one that those who first embraced both were society's more affluent members. Nevertheless, the Department of Commerce, the Federal Communications Commission, and outside lobbying

groups such as Consumers Union are concerned that many households may be on the wrong side of a "digital divide."

Incontrovertibly, poor people and minorities in the United States are less likely to own computers and be connected to the Internet than are middle- and upper-income citizens in general and whites in particular. What should we do? Policymakers have made several proposals. One—which died in the just-ended 106th Congress—would have extended the low-income earned income tax credit by up to \$500 for 50 percent of the cost of "computer technology or equipment" used to connect to the Internet. A new subsidy program might prove politically attractive, especially to its recipients, but is there any real need for such a program? After all, if low-income households eschew personal computers and Internet connec-

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tions, are they not telling us that they have more pressing needs?

Measuring the Digital Divide

For nearly two decades the Census Bureau has used its Current Population Survey to measure the extent to which households have telephone service. Telephone "penetration" has increased steadily across the population, but a 6-8 percentage point gap remains between telephone subscription in households with a white head and those headed by a black or Hispanic. Much of that gap may be attributed to income differences—all racial groups in households with annual incomes of \$75,000 or more have essentially the same rate of telephone subscription. But low-income black and Hispanic households are significantly less likely (8-12 percent at annual incomes of less than \$15,000) to have a telephone at home than are white households of similar income.

These disparities cannot be attributed to the high price of a residential connection to the telephone network. Regulators have kept rates for local residential service below its long-run incremental cost for decades, and direct subsidies are available to low-income households to reduce the cost further. For various reasons, including difficulty controlling long-distance spending, some poor and minority households find the benefits of a telephone in their residences—as



Government policymakers should relax and let the booming economy close the digital divide.

opposed to access to a nearby pay phone or, now, a cellular phone—less compelling than do more affluent, white households. About 20 percent of very low income black and Hispanic households still feel that a wired telephone connection in their homes is simply not worth the roughly \$13 a month charge, after federal and state subsidies, for unlimited local service.

The "analogue divide" in current

voice telephone service is narrowing, however, largely because of the strong income growth of the 1990s. About 95 percent of black and Hispanic households with annual incomes of more than \$15,000 now have a wired telephone in their homes. But greater affluence has made life more complicated. In addition to the telephones, refrigerators, television sets, washing machines, and stereo equipment that have become ubiquitous in

American homes, comes now the personal computer. The PC is capable of performing many tasks, some that are very attractive to households. It can assist in financial management and planning, provide access to stored information, play recorded music, and connect to e-mail and other services over the Internet.

At first a luxury to which only a few aspired, the household personal computer is now much more widely afford-

able. Today, a rudimentary Pentium-based machine with a modem and a standard 15-inch monitor can be purchased for as little as \$400—about the price of a large color television set. Internet connections can be had for \$15 a month, or even for free if the subscriber does not mind being deluged by advertisements.

Still, this downward trend in prices does not guarantee the ubiquity of household PCs and household connections to the Internet. As of December 1998, the most recent period for which the Census Bureau has published data, “only” 42.1 percent of U.S. households had a personal computer, and “only” 22.2 percent accessed the Internet from home. A private market research firm, TNS, estimates that these numbers had grown to 61 percent (personal computers or similar devices) and 52 percent (Internet connections) by the second quarter of 2000. But the digital divide was clearly in evidence.

While 46.6 percent of white, non-Hispanic households had a computer, only 23.2 percent of black households and 25.5 percent of Hispanic households had a PC in 1998. Internet use was somewhat lower, but the digital divide exists here too. Among white households, 26.7 percent used the Internet at home, as against only 9.2 percent of black households and 8.7 percent of Hispanic households. Thus, the digital divide is greater for Internet use than for computer ownership even though the Internet is available to everyone for about \$15 to \$20 a month (see table 1).

What Causes the Divide?

Using Current Population Survey estimates of household computer ownership in 1994, 1997, and 1998 and of Internet use in 1997 and 1998, I have estimated the determinants of household demand for each. Clearly, computer ownership and Internet use depend on income, occupational status, residence (urban or not), household size, and whether a household is male-headed. But after correcting for these variables, I found that computer ownership is only slightly lower—and Internet

Table 1.

Computer Ownership and Internet Use in U.S. Households, 1994 and 1998

PERCENT HOUSEHOLDS	1994 COMPUTER IN HOME	1998 COMPUTER IN HOME	1998 USE INTERNET AT HOME
White	27.1	46.6	26.7
Black	10.3	23.2	9.2
Hispanic	12.3	25.5	8.7

Source: Bureau of the Census, Current Population Survey.

use no lower—for Hispanic households, while both are significantly lower for black non-Hispanic households.

The Good News

While it is true that low-income households, black households, and to a lesser extent Hispanic households have less contact with the digital society at home, these groups are narrowing the gap over time. A good way to demonstrate that is to estimate the determinants of PC ownership based on the 1994 data from the Current Population Survey, and to predict household computer ownership in 1998 based on 1998 income and demographics. It turns out that the 1994 data underpredict computer ownership for low-income households by 99–224 percent, as compared with only 41 percent for households earning more than \$75,000 a year. Similarly, the 1994 data underpredict computer ownership for white households by 82 percent, but by 104 percent for black households. In short, lower computer prices, income growth, and greater interest in computers by poor and nonwhite households have closed a good deal of the divide in just four years.

Should We Worry?

What if the digital divide were not being closed? Given systematic differences in consumption across demographic groups—the “music gap” between generations, the “pickup truck gap” among vehicle owners—should it be a matter of public concern if some groups in our society shun the \$400 computer and a \$15 a month (or less)

connection to the Internet and use their income on something else?

It is possible that “consumption externalities” in computer and Internet use are not being exploited. Plainly speaking, you and I would gain if others connect to the Internet if these others are people that we wish to communicate with and have them reciprocate. But computer and Internet use by households is growing rapidly, suggesting that more and more of any such externalities are being exploited every day. Some households’ failure as yet to join the Internet world may simply reflect a lag in recognizing the benefits of its use and a lack of friends and associates who communicate through it.

It is also possible, even likely, that households on the wrong side of the digital divide would improve their educational, cultural, and professional status if they owned a PC and connected to the Internet. But such improvements are internal to these households and do not call for extraordinary market incentives for them to become connected. Households can choose for themselves.

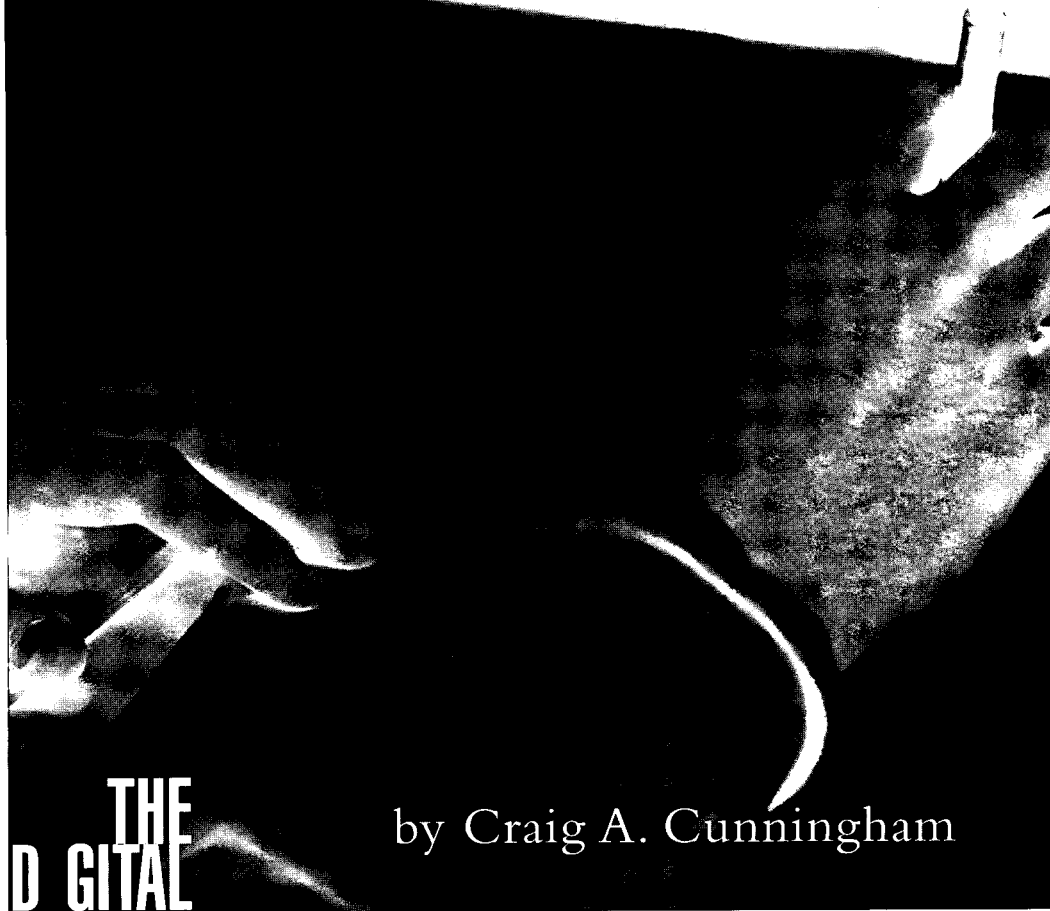
The Imprudence of a New Subsidy Program

Would a new subsidy program directed at low-income households, minorities, or rural households have much effect? No one knows. We do not know how large a subsidy it would take to increase household computer and Internet use measurably. We do know that any program that made much of a difference could be very expensive. For instance, current low-income telephone subsidies cost about

one-third of the local monthly telephone bill, yet their effectiveness is subject to considerable dispute. If we assume that the annual cost of a computer and Internet service is about \$380 a year, a program similar to the telephone subsidy would cost about \$127 per household opting for the subsidy. Even if only 5–10 million of the country's approximately 40–50 million households not owning a computer or connecting to the Internet were to opt for the subsidies, the cost would be \$635 million to \$1.27 billion a year. And the subsidies would likely become a permanent part of the political landscape, whether needed or not, much as the low prices of telephone connections in rural areas have become untouchable.

Even more ill-advised is a nascent move toward trying to assure that all areas of the country have access to the new high-speed, "broadband" connections now being rolled out by telephone and cable companies. These new services require billions in investment to reconfigure existing networks and billions more to connect subscribers. A 1999 analysis by the FCC, *Deployment of Advanced Telecommunications Capability: Second Report*, laments that such services are not uniformly available throughout the country. Not surprisingly, the cable and telephone companies have initially targeted higher-income, urban areas to cover their capital costs. At this juncture, the deployment of these services is extremely risky because no evidence exists on the demand for them. With only about 4 percent of the nation's households subscribing to such services, it is surely unwise for a government agency to pressure companies to roll out the services in high-cost and low-income areas before they are sure they have a winning product.

Government policymakers should relax and let the booming economy close the digital divide. To do otherwise risks committing a great deal of taxpayer money to technologies that could well be obsolete in a few years or that many households simply do not want. ■



THE
DIGITAL

by Craig A. Cunningham

DIVIDE

Improving Our Nation's Schools through Computers & Connectivity

In the name of improving the nation's schools and closing the digital divide, the federal government has embarked on a massive program to connect every school to the Internet. School districts too are spending vast sums on computers, software, and technical support. Yet many of America's teachers are unprepared to use computers in their classrooms. According to a 1999 study, about 1.3 million of the nation's 3 million elementary and secondary teachers feel only "somewhat" or inadequately prepared to integrate educational technology into their teaching.

Craig A. Cunningham is director of curriculum for the Chicago Public Schools/University of Chicago Internet Project (CUIP) and director of the Web Institute for Teachers at the University of Chicago.

Using Computers in Schools

The billions of public dollars devoted to wiring the nation's schools will, in theory, stimulate learning in three ways. At bottom, computers can serve as electronic workbooks, delivering instruction at a pace individualized for each student. On a more sophisticated level, they can simulate real-world experiences. They can also be productivity tools, enabling students to gather and learn from information more efficiently.

So far, the computer revolution has borne most fruit in the classroom as a

usually easy and handled with a simple contract between the vendor and the school.

But electronic workbooks do almost nothing to address higher-order thinking skills. And although they may improve students' performance on standardized tests (because the tasks in the preprogrammed curriculum are so similar to the tasks found on multiple-choice tests), they don't address the deficits of many inner-city students in analytical or systematic thinking, nor do they prepare students to use com-

pute these resources to find patterns of similarity and difference, and compare their hypotheses or tentative findings with those of other students around the world. Their progress is assessed through tasks embedded in the learning process itself: through some "performance" or "product," rather than a paper-and-pencil test. Their teachers become problem-posers, creating their own curricula to address their students' interests and needs in the light of educational standards and learning continually, both about their subject matter

Ironically, today's investment in computing for schools is unlikely to close the widening gap between information technology haves and have-nots.

glorified workbook. Electronic workbooks do indeed improve students' basic skills, enabling them to participate in higher levels of education. And the workbooks require no teacher expertise. Even teachers and administrators who are barely computer literate are attracted to the promise of prepackaged, networked computer-based learning systems—such as CompassLearning (formerly Jostens), Computer Curriculum Corporation, or Skills Bank—that enable them to track student progress on basic skills or assign specific tasks to particular students. These systems are especially appealing to inner-city or underperforming schools because they require almost no changes in school structures or major investment in teacher training; indeed, it is possible to install and run a computer lab using one of these systems with only one trained teacher, who takes each class of students in turn, giving the regular classroom teacher a "prep period" and requiring absolutely no new skills or knowledge. And because all the computers in the lab are generally identical and similarly configured, maintenance is

puters for performing real-world tasks.

Using computers at a higher level—to provide the virtual reality of journeying west across the plains on a Conestoga wagon, investing funds in a stock portfolio, or dissecting a frog—requires much more of teachers. They must have ready access to computers in the classrooms—requiring not only more computers, but also more complex technical support—as well as increased familiarity with the computer and software. Teachers must also alter their curricula, so that the simulation is not just an "add-on" but a complement to their larger instructional goals. While intelligent and motivated teachers can master these programs, it is nearly impossible to push reluctant or hidebound teachers to use simulations effectively.

Realizing a vision of computers as productivity-enhancing mindtools is more difficult still. It requires transforming classrooms into information-rich workrooms, in which students use the Internet as a huge repository of real-world data, images, text, and other resources. They gather resources that are relevant to real problems, manipu-

late these resources to find patterns of similarity and difference, and compare their hypotheses or tentative findings with those of other students around the world.

This dream is not impossible. For the past 10 years, the Union City, New Jersey, school district has been retraining teachers and building a full K–12 curriculum based on the use of technology. The effort has paid off—students' educational attainment has risen in proportion to increases in spending. But that district is relatively small; it has both corporate and state support for technology purchases; and it has a visionary director of curriculum who is committed to make long-term changes in the district's teaching and learning. Replicating that success widely would be difficult indeed.

Needed: Teacher Training

While many teachers have the necessary intelligence and disposition to succeed in a wired classroom, the teaching profession as a whole is rife with people who prefer delivering prepackaged curricula, using traditional tools, and assessing student progress in traditional ways.

Over the next decade more than 2 million new teachers will be hired. If



these new teachers are more technologically oriented or more enthusiastic about new modes of teaching and learning, perhaps computers can begin to realize their educational potential. But according to a 1999 *Education Week* study, teachers in their first five years of service are no more likely to integrate technology into their teaching than are 20-year veterans. Even though younger teachers tend to be more astute in their own use of computers, the skills don't carry over to their teaching. Perhaps certain barriers to technology integration are inherent in the nature of teaching and learning; if so, the barriers are not well understood.

Meanwhile, many teacher training institutions fail to use computers effectively to train teachers. (Teacher educators as a group are even more technologically inept than are elementary and secondary teachers.) And schools of education continue to attract the least intelligent group of students of any field of higher education. Even new teachers, especially in traditionally underserved areas such as the inner city and rural districts, serve only passably in their tradi-

tional roles as deliverers of prepackaged curriculum, using textbooks and worksheets. Even if these tools become computerized (which is expensive and often less efficient than paper and pencil), most teachers will be unable to integrate technology into the curriculum in educationally significant ways.

So where does this leave us as a nation, trying to improve our nation's schools while creating a more equitable society? Ironically, today's investment in computing for schools is unlikely to close the widening gap between those in our society who have access to, and know how to use, information technologies and those who do not. Indeed, placing the computer at the center of school routines will only increase the educational advantage of students for whom computers are just a fact of daily life. Putting computers in the classrooms of such students may increase their opportunities to learn (provided that their teachers know what to do with the computers). But for students without such a comfort level, the demands of the computer will be a distraction from reading and writing and figuring or will

become just a very expensive version of a textbook or workbook.

Rather than simply providing money to connect classrooms to the Internet, we need a massive effort at teacher training—not one-shot in-service workshops, but comprehensive professional development that makes possible the kinds of changes in instruction that improve student performance on higher-level thinking tasks.

What we don't need is a mindless pursuit of educational technology for its own sake, without regard for the opportunity costs (what we would spend the money on if we didn't have to pay for computers and access), the educational effects (enhancing basic skills as against improving higher-order thinking skills), or the substantial changes in schooling that may be necessary to use technology effectively. Unfortunately, it may be several decades before we understand these issues well enough to make good choices on a national level. By then, economic forces, rather than educational ones, will probably have already determined how computers will change society—and our schools. ■

Access
Denied

Whom to Protect And How?

by Robert J. Blendon, John M. Benson, Mollyann Brodie,
Drew E. Altman, Marcus D. Rosenbaum, Rebecca Flournoy,
and Minah Kim

The United States is now in the second stage of a major technological transformation. What began in the 1980s as the Computer Revolution has extended its reach and become the Computer and Internet Revolution. The second stage of the revolution is not only transforming American life, but also leading to calls for federal government protection from perceived threats presented by specific Internet content. Because of First Amendment concerns and the difficulty of regulating this international technology, the government will find it hard to provide the kind of oversight the public wants.

During the first stage of the Computer and Internet Revolution, computer use grew rapidly. Between 1985 and 1999, the share of Americans who used a computer at work or at home more than doubled, from 30 percent to 70 percent. The increase in home computer ownership was even more striking, quadrupling from 15 percent in 1985 to 60 percent by century's end (table 1).

The Internet stage of the revolution started in the mid-1990s. Only five years ago, fewer than one in five Americans (18 percent) had ever used the Internet. As the new century begins, nearly two-thirds (64 percent) have used the Internet some time in their lives. In 1995 only 14 percent of Americans said they went online to access the Internet or to send or receive e-mail. By 1997 that share had more than doubled, to 36 percent, and today more than half (54 percent) go online. Virtually all Americans younger than 60 say they have used a computer (92 percent), and most have used the Internet (75 percent) or sent an e-mail message (67 percent).

The rapid spread of the new technology is not without precedent. Television ownership in the United States exploded from 6 percent in 1949 to 52 percent in 1953 to 83 percent by 1956. Still, the increase in computer use and, in the second wave, Internet use is remarkable.

Although much is made of the Internet's almost limitless capabilities, at this point people are most likely to use it to get information. Americans use the Internet at home to learn

about entertainment, sports, and hobbies (38 percent), current events (37 percent), travel (33 percent), and health (28 percent). Fewer use the Internet to shop (24 percent), pay bills (9 percent), and make investments (9 percent).

A Beneficent Revolution

America's Internet Revolution is taking place among people already disposed to believe strongly in the benefits of new technology. When asked to rate on a scale of 0 to 100 their interest in 11 issues, Americans ranked new medical discoveries highest (an average of 82), followed in fourth and fifth places by new scientific discoveries (67) and new inventions and technologies (65).

Large majorities of Americans believe that science and technology make lives healthier, easier, and more comfortable (90 percent) and that science and technology will provide more opportunities for the next generation (84 percent). Three-fourths of Americans (74 percent) believe that the benefits of scientific research have outweighed the disadvantages.

The experiences of the past two decades have left most Americans feeling quite positive about the general impact of computers on national life and receptive to the possibilities of the Internet. Asked to choose, from a list of eight options, the two most significant technological developments of the 20th century, Americans put the computer (named by 62 percent) at the top of the list by a large margin over the automobile (34 percent), television (21 percent), and the airplane (16 percent). The landslide vote for the computer may be due in part to its novelty, but Americans clearly regard the computer as a major technological discovery.

Most Americans see the computer's impact on society as mainly positive. Just over half believe that the computer has given people more control over their lives (17 percent believe

Robert J. Blendon, of the John F. Kennedy School of Government and the Harvard School of Public Health; John M. Benson and Minah Kim, of the Harvard School of Public Health; Mollyann Brodie, Drew E. Altman, and Rebecca Flournoy, of the Henry J. Kaiser Family Foundation; and Marcus D. Rosenbaum of National Public Radio are part of a team conducting ongoing polling on Americans' attitudes about domestic policy issues.

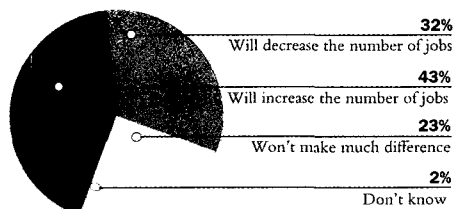
Table 1. Share of the Public with Access to Computers at Home and at Work, 1985–99

PERCENT	1985	1990	1995	1997	1999	
					(a)	(b)
Computer at work	25	32	39	38	42	44
Computer at home	15	22	36	42	54	60
Computer at neither	70	58	46	43	35	30

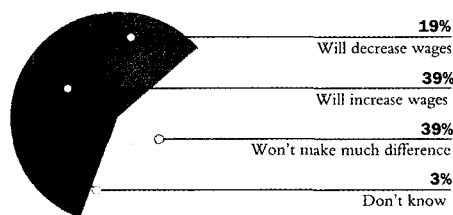
Source: NSF, 1985–1999 (a); NPR–Kaiser–Kennedy School, 1999 (b)

How the Public Assesses the Impact of the Computer on American Life: Employment Opportunities

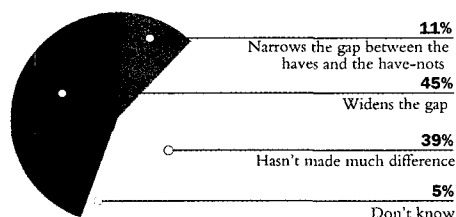
Growing use of computers in the workplace



Use of computers in the workplace



Access to computers



it has diminished their control). More than eight out of ten see computers as making life better for Americans (9 percent think computers are making life worse). Sixty-eight percent believe the Internet is making life better (14 percent believe it is making life worse). Americans are more evenly divided in their views on the impact of television: 46 percent believe that TV is making life better, 34 percent think it is making life worse.

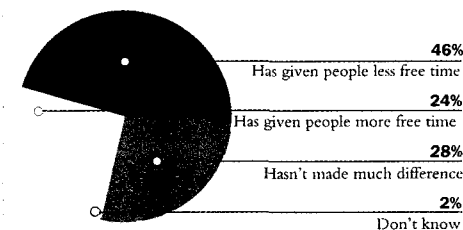
Most Americans also view the computer industry positively. More than three out of four (78 percent) think computer software companies serve consumers well, while only 7 percent think their service is poor. Only banks (73 percent) and hospitals (72 percent) have comparably positive ratings, but both have higher negatives (24 percent each). Nearly two-thirds (65 percent) of Americans believe that the Internet industry is doing a good job serving its consumers; again, only 7 percent think it is doing a bad job.

Despite some early fears, most Americans do not think the use of computers in the workplace displaces workers or depresses wages. A plurality (43 percent) think the growing

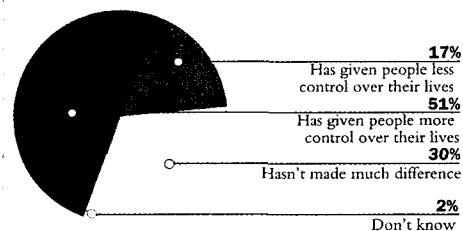
Most Americans see the computer's impact on society as mainly positive. Just over half believe that the computer has given people more control over their lives

How the Public Assesses the Impact of the Computer on American Life: Personal Lives

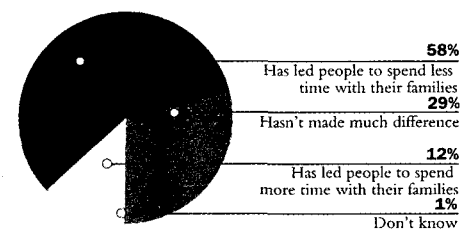
Use of computers



Use of computers



Use of computers



use of computers will create more jobs; 32 percent think it will mean fewer jobs; about a quarter think it will not make much difference. Americans are evenly divided, at 39 percent each, on whether the use of computers will raise wages or not have much effect; but only 19 percent believe it will lower wages.

In two areas—the amount of free time and time spent with family and friends—Americans do not believe computers have improved life. Only one-fourth (24 percent) of the public believes that computers have given people more free time. Nearly half think computers have actually reduced free time. And more than half (58 percent) say computers have led people to spend less time with families and friends.

What Role for Government?

The first wave of the Computer and Internet Revolution led many Americans to see a role for government in narrowing a “digital divide” in American society, a problem that continues to concern the public today. Nearly half (45 percent) believe that access to computers widens the gap between the haves

Table 2. What the Public Believes the Government Should Do about Key Issues Involving the Internet

PERCENT	ISSUE IS A PROBLEM		ISSUE IS NOT A PROBLEM	DON'T KNOW
	GOVERNMENT SHOULD DO SOMETHING	GOVERNMENT SHOULD NOT BE INVOLVED		
Dangerous strangers making contact with kids	79	15	3	1
The availability of pornography to kids	75	20	4	1
The availability of information about how to build bombs and other weapons	75	15	8	1
False advertising	62	20	12	4
Pornography and adult entertainment	61	26	10	3
The ability to purchase guns	61	14	18	5
Loss of privacy	54	29	14	2
Hate speech, information that attacks people based on their race, religion, or ethnicity	53	27	15	5
Violent games	51	31	15	3

Source: NPR-Kaiser-Kennedy School, 1999

and the have-nots, while only 11 percent believe that it narrows the gap; 39 percent think it has not made much difference. A majority of Americans (57 percent) believe the government should help low-income people get access to computers and the Internet, and 78 percent say the government should help low-income children.

The Internet Revolution is leading to a broader range of public concerns, accompanied by calls for more government involvement in specific areas. Eighty-five percent of Americans cite as a major problem the possibility of dangerous strangers making contact with children; 84 percent, the availability of pornography to children; and 73 percent, the availability of information about how to build bombs and other weapons.

In addition, more than half (56 percent) of Americans regard the loss of privacy as a major problem with computers or the Internet. Although few (4 percent) have ever had an unauthorized person gain access to their financial records or personal information over the Internet, privacy concerns are increasing demands for regulation. More than half (59 percent) of Americans worry that an unauthorized person might gain

such access, including 21 percent who say they are very worried. More than three-fourths (81 percent) of people who ever go online say they are concerned about threats to their personal privacy when using the Internet, including 42 percent who say they are very concerned.

What do these trends indicate about a possible new role for government in regulating the Internet? On the one hand, the coming years will witness an upsurge in use of the Internet for a wide variety of purposes, and the public is unlikely to want across-the-board government regulation of the Internet. On the other, most Americans are likely to support legislation to address their specific concerns about the content of the Internet.

Many people are wary of having the government regulate what can be put on the Internet, but they are more willing to accept regulation when it comes to specific threatening content. At least at this point, only about a third of Americans see the need for more government regulation of the Internet industry or the general content of the Internet. But when specific content seen as threatening, such as pornography and bomb-making information, is mentioned, 60 percent favor

POLLS USED

The results reported here are drawn primarily from a survey conducted by the National Public Radio-Henry J. Kaiser Family Foundation-Kennedy School of Government survey project, November 15-December 19, 1999. Other data come

from polls by the National Science Foundation (1985, 1990, 1995, 1997, 1999); the Pew Research Center for the People and the Press-Princeton Survey Research Associates (1995, 1997, 2000); CBS News-New York Times (1995); CBS News (1999); the Gallup Poll (1949, 1953,

1956); Harris Interactive (2000); the Henry J. Kaiser Family Foundation-Kennedy School of Government (2000); Louis Harris & Associates-Dr. Alan F. Weston-Privacy and American Business-Price Waterhouse, Inc. (1998); and Newsweek-Princeton Survey

Research Associates (1999). Results of the NSF polls may be found at <http://www.nsf.gov/sbe/srs/seind00/pdf>. Results of all other polls cited may be obtained from the Roper Center for Public Opinion Research, Storrs, Connecticut.

government restrictions, even if they would impinge on freedom of speech. More than half (57 percent) say that "the federal government needs to regulate what is on the Internet more than television and newspapers because the Internet can be used to gain easier access to dangerous information."

Three-quarters of Americans say the government should "do something" about the possibility of dangerous strangers making contact with children and about the availability both of pornography to children and of information on how to build explosives (see table 2). A majority also says the government should do something about false advertising (62 percent), the availability of guns (61 percent), pornography (61 percent), the loss of privacy (54 percent), and hate speech (53 percent).

More Americans are worried about specific threats like pornography and bomb-making information on the Internet than about First Amendment issues involved in regulating these threats. When asked which worried them more, 53 percent said they were more concerned that government would not get involved enough in regulating pornography and bomb-making information on the Internet. Only 26 percent were more concerned that government would get too involved in censorship of the Internet.

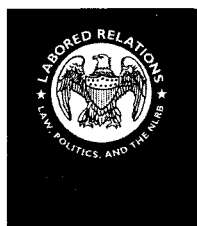
Public concerns about specific threats on the Internet are not likely to dissipate as more people go online. While Internet users are less likely than nonusers to believe that the con-

tent of the Internet needs more regulation than TV or newspaper content, about half of Internet users (as against 65 percent of nonusers) favor this additional regulation in general. In addition, a majority of Internet users believe the government should do something about most of the same specific threats mentioned by nonusers.

The next decade will see an explosion of growth and change in the world of the Internet. Like the advent of television half a century ago, the Internet Revolution will lead to fundamental and in most cases positive changes in the way Americans live. The number of Americans who use the Internet for nearly every activity is likely to double or triple.

Between a Rock and a Hard Place

In the midst of this extraordinary ferment, public pressure will build in favor of more government involvement in regulating specific parts of the Internet's content. Regulatory efforts will raise a number of First Amendment issues, if not with the public, at least within the judicial system. Given that information on the Internet flows almost seamlessly across national borders, the U.S. government—or any other—will find it extremely difficult to limit access to information the public thinks is dangerous. Policymakers are likely to be caught between growing public pressure to protect against perceived threats to national and personal well-being and the limits of their ability to regulate specific Internet content. ■



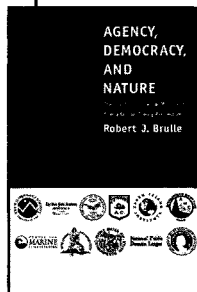
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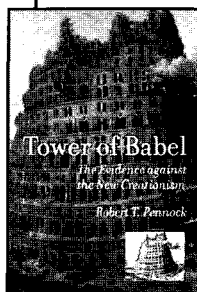
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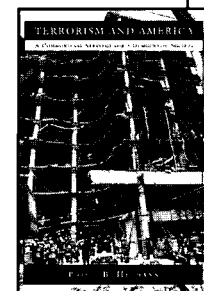
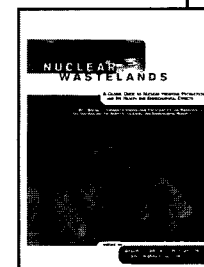
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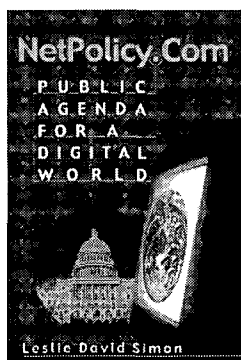
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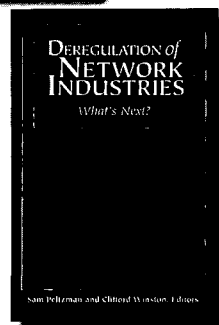
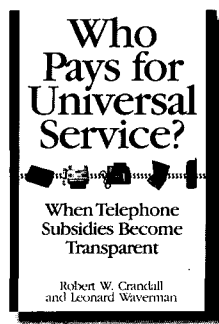
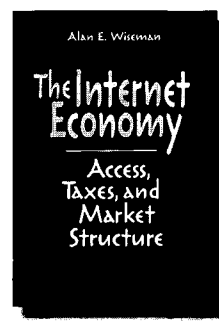
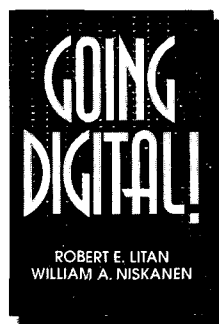
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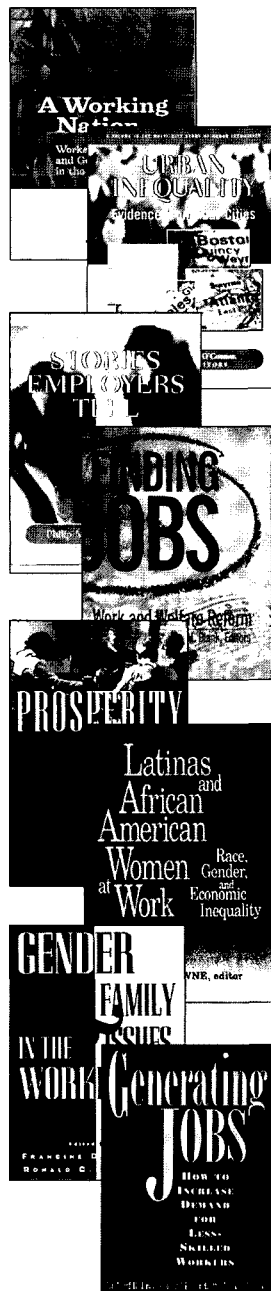
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